WOODS HOLE OCEANOGRAPHIC INSTITUTION

Reference No. 63-42

OCEANOGRAPHIC AND UNDERWATER ACOUSTICS RESEARCH

conducted during the period
1 May - 31 October 1963

WOODS HOLE, MASSACHUSETTS

WOODS HOLE OCEANOGRAPHIC INSTITUTION
Woods Hole, Massachusetts

Reference No. 63-42

OCEANOGRAPHIC AND UNDERWATER ACOUSTICS RESEARCH

conducted during the period
1 May - 31 October 1963

Submitted to Undersea Warfare Branch
Office of Naval Research

Under Contracts Nonr-4029(00)NR261-102 and Nonr-3243(00) NR261-136

November 1963

J. B. Hersey

J. B. Hersey, Chairman
Department of Geophysics

TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

LIST OF FIGURES:

TABLE OF CONTENTS

ABSTRACT

This is a report of the research program under contracts Nonr-4029 (1 May - 31 October 1963), and Nonr-3243 (1 May - 31 October 1963). Both contracts are with the Office of Naval Research, Code 466. Contract Nonr-4029 is a continuation of Contract Nonr-1367.

Under Contract Nonr-4029, ATLANTIS II and CHAIN, in May and August, were employed in searching for the sunken submarine THRESHER by various means. Under the same contract, activities were devoted also to the development of systems or components of systems for search and for navigational control required in such operations. One system of submerged navigation was employed for locating suspended instruments by acoustic ranging from the ship. A second navigation system was also tested which depends on acoustic ranging either from the ship or from the suspended instrument to a hydrophone buoyed near the bottom. This hydrophone is connected to a radio link in a surface buoy. This system will be useful not only for navigation but also for bottom reflection studies. A program has been started to print and mount all photos taken by WHOI on the THRESHER search; it will be coordinated with other similar efforts in the continuing investigation of the disaster. Under Contracts Nonr-4029 and Nonr-3243 considerable progress has been made in other research, which is described in this report.

INTRODUCTION

This is a report of the research program under contracts Nonr-4029 (1 May 1963 - 31 October 1963), and Nonr-3243 (1 May 1963 - 31 October 1963.) Both contracts are with the Office of Naval Research, Code 466. Contract Nonr-4029 is a continuation of Contract Nonr-1367(00).

The activities of scientists and engineers under Contract Nonr-4029 were largely devoted to the search for the sunken submarine THRESHER and on the development of systems or components of systems for search and for navigational control required in such operations. Specifically, during cruises in May and August both ATLANTIS II and CHAIN were employed in searching for THRESHER by means of cameras, suspended echo-ranging apparatus, echo sounders, and electrical self-potential probes. In addition, one system of navigation was employed for locating suspended instruments by acoustic ranging from the research ship. This system is taken directly from previous work in connection with navigating rock dredges and has been described previously (WHOI Ref. No. 63-27, p. 8). Another aid to submerged navigation was tested with limited success. It consisted of a radio acoustic buoy (taken over from the seismic reflection program) which was connected to a hydrophone suspended 600 feet above bottom in 8500 feet of water by means of a single-conductor steel-clad well-logging cable. The combination was anchored to a 1500 lb. anchor by manila line. The objective of this design was to provide a navigational reference (the hydrophone) which would not wander greatly as surface buoys do. The system was planted and it operated well for about 12 to 14 hours. The anchor was then dislodged and the whole system drifted away causing a fault in the electrical cable. The successful operation indicates that further development is well warranted and that such a scheme will prove useful not only for navigation but also for bottom reflection studies.

Since the August cruise of CHAIN a program has been started to print and mount, both in stereo and as a photo mosaic, all photographs taken by WHOI during the THRESHER search. This program will be coordinated with other similar efforts in the continuing investigation of the THRESHER disaster.

Despite the great preoccupation with the THRESHER search considerable progress has been made in other research under Contracts Nonr-4029 and Nonr-3243 as discussed below.

PAPERS

The following papers, prepared under Contract Nonr-4029 or Contract Nonr-1367 and published during this period:

<u>WHOI Contr. No. 1221.</u> Acoustic Studies at Capelinhos Volcano, Azores, by A. F. Richards, J. B. Hersey and W. T. McGuinnes. Memoria dos Serviços Geológicos de Portugal, No. 9 (N.S.), pp. 27-33.

<u>WHOI Contr. No. 1329.</u> Bottom Currents on the Blake Plateau, by R. M. Pratt. Deep-Sea Research, 1963. Vol. 10, pp. 245-249. (Prepared also under BuShips Contract NObsr-89464.)

<u>WHOI Contr. No. 1352.</u> The Physical Dimensions of Spectrum Levels and of Spectral Densities of Acoustic Power, Energy, and Related Quantities, by Lincoln Baxter II. Journal of Acoustical Society of America, 1963. Vol. 35 (6):923-924.

<u>WHOI Contr. No. 1375.</u> Adaptation of Sonar Techniques for Exploring the Sediments and Crust of the Earth Beneath the Ocean, by J. B. Hersey, S. T. Knott, D. D. Caulfield, H. E. Edgerton and E. E. Hays. The Journal of the British Institution of Radio Engineers, 1963. Vol. 26, No. 3, pp. 245-250.

<u>WHOI Contr. No. 1396.</u> A Region of Uniform Heat Flow in the North Atlantic, by John Reitzel. Journal of Geophysical Research, 1963. Vol. 68, No. 18, pp. 5191-5196.

The following contribution was prepared by the author privately with partial clerical and drafting support from WHOI, but it is believed to be of interest to the Office of Naval Research:

Hersey, J. B. Continuous Reflection Profiling. Interscience Publishers, 1963. The Sea, Vol. 3, The Earth Beneath the Sea, Chapter 4, pp. 47-71.

The following papers were submitted for publication during this period under Contract Nonr-4029:

WHOI Contr. No. 1387. The Geology of the Western Approaches of the English Channel II. Geological Interpretation Aided by Boomer and Sparker Records, by D. A. Curry, J. B. Hersey, E. Martini, and W. F. Whittard. Submitted to the Royal Society of London.

WHOI Contr. No. 1401. Real-Time Digital Computer Acquisition and Computation of Gravity Data at Sea, by R. Bernstein and C. O. Bowin. Submitted to IEEE Transactions on Geoscience Electronics.

WHOI Contr. No. 1424. Chain and Romanche Fracture Zones, by B. C. Heezen, E. T. Bunce, J. B. Hersey, and M. Tharp. Submitted to Deep-Sea Research (Prepared also under Contract Nonr-2196.)

The following papers were submitted for publication during this period under other contracts as noted but are believed to be of interest to the Office of Naval Research:

WHOI Contr. No. 1393. The 20-Cycle Signals and Balaenoptera (fin whales), by W. E. Schevill, W. A. Watkins, and R. H. Backus. Submitted to Pergamon Press for publication in Marine Bio-Acoustics. Contract NObsr-89464.

WHOI Contr. No. 1404. Underwater Sounds of Cetaceans, by W. E. Schevill. Submitted to Pergamon Press for publication in Marine Bio-Acoustics. Contract NObsr-89464.

WHOI Contr. No. 1418. Physeter Clicks, by R. H. Backus and W. E. Schevill. Submitted to Proc. First International Symposium on Cetacean Research. Contract NObsr-89464.

WHOI Contr. No. 1433. Listening to Cetaceans, by W. A. Watkins. Submitted to Proc. First International Symposium on Cetacean Research. Contract NObsr-89464.

WHOI Contr. No. 1434. Cardiographic Recordings and Air-Borne Sounds from *Globicephala melaena* (Pot-head Whale), by A. W. Senft and Jane F. Broughton. Submitted to Journal of Marine Research. Contract NObsr-89464.

The following reports have been completed during this period under Contract Nonr-4029 or in conjunction with other contracts as noted:

WHOI Ref. No. 62-42. Track Charts, Bathymetry and Location of Observations of ATLANTIS Cruise #280, Atlantic Ocean, 13 - 23 June 1963, ATLANTIS Cruise #281, Atlantic Ocean, 26 June - 1 July 1963, by S. L. Thompson, R. M. Pratt, W. Dow, and W. Dunkle.

WHOI Ref. No. 63-6. Inverted Echo-Sounder (U), by W. Dow and S. L. Stillman.

WHOI Ref. No. 63-11. Track Charts, Bathymetry and Location of Observations of BEAR Cruise #280, Atlantic Ocean, 10 - 30 July 1962, by E. T. Bunce. (Prepared also under Contract Nonr-2196.)

WHOI Ref. No. 63-14. Track Charts, Bathymetry and Location of Observations of CHAIN Cruise #28, Atlantic Ocean, 6 - 24 July 1962, by R. M. Pratt. (Prepared also under Contract Nonr-2196.)

WHOI Ref. No. 63-16. A System for the Centralized Recording of Remotely Detected Seismic Data by F. R. Hess.

WHOI Ref. No. 63-23. Track Charts, Bathymetry and Location of Observations, CHAIN Cruise #7, North Atlantic Ocean, Mediterranean Sea, 8 April - 17 August 1959, by R. M. Pratt and W. M. Dunkle. (Prepared also under Contracts Nonr-2196 and NObsr-89464.)

OCEANOGRAPHY

Internal Waves (Mr. Perkins, and Dr. Voorhis).
(Contracts Nonr-4029 and Nonr-3243)

With the advent of towed thermistor chains, there has come an awareness that internal waves, evidenced by irregularities in the observed isothermal surfaces, are a common feature of the near-surface ocean layers. While the existence of internal waves has been recognized for over a hundred years, difficulties in observation and analysis have prevented quantitative descriptions of them. The present study is devoted to obtaining such a description by constructing their directional energy spectrum. The directional energy spectrum, which describes the energy of the waves as a function of their wavelength and direction of propagation, has been shown to contain nearly all important statistical properties of wave systems.

There are three sets of data now being studied. They were made near Madiera in September, 1961, on the equator near 30° West in March, 1963, and about 100 miles northwest of Bermuda in June, 1963. In each case, the observations were made by recording the output of a thermistor while it was towed at a fixed depth of roughly 100 meters over an eight-legged, star-shaped pattern, the legs being separated by angles of about 45°. From each set of observations, combined with observations of the local density structure, the directional spectrum can be found.

During the present report period, the data have been reduced to punched cards or digital magnetic tape for analysis by computer and most of the relevant programs have been written. Preliminary results have been obtained showing a rapid increase in energy for wavelengths greater than 1000 meters. A very interesting result will be the extent to which the waves have a preferred direction of travel. This could lead to a better understanding of the driving mechanism. There are tentative indications that the waves have a highly preferred direction of travel.

Concurrent with the observations on the equator and those near Bermuda, records from a fixed temperature recorder were made. They both indicate a rapid increase in energy for wave periods greater than about 5 hours. Each one also provides a cross check on the corresponding directional spectrum.

Underwater Sound Velocimeter (Mr. Stillman and Mr. Nowak).
(Contract Nonr-4029)

No new sound velocity measurements were carried out under this contract. However, Dr. Hays and others have carried out a considerable program of measurements from ATLANTIS II in the Indian Ocean. A secondary temperature standard (± .01°C) has been established for the calibration of velocimeters using a mercury thermometer of high quality calibrated by the National Bureau of Standards in conjunction with a constant temperature bath.

A program is being developed, using the digital computer facility at the Woods Hole Oceanographic Institution to speed and improve the accuracy of the calibration procedure.

The model TR-2 velocimeter has been redesigned to try to eliminate the cause of the theoretical "Dishing" or "Bowing" error. [1] This plate has been relocated to eliminate the pressure differential. The modified instrument will be calibrated and tested as soon as possible.

An advanced velocimeter, ACF Industries, Model TR-4 has been purchased. This instrument has twice the accuracy of the TR-2 models.

Replacement of the depth meter used in the velocimeter system has nearly been completed. [2]

A programmer was designed and constructed to provide faster data acquisition. The device was designed for use with the Ramsay type velocity-depth-temperature system but may be modified for use with the inverted echo sounder system.

All velocimeters used at WHOI are being modified for direct input into the IBM computer system on R/V CHAIN. This will permit much faster data processing for routine lowerings.

---

[1] An Improved Sing-Around Velocimeter, E. M. Zacharias and D. E. Willig, ACF Electronics AR No. 1681, June 14, 1963.

[2] See above "Inverted Echo Sounder".

SUBMARINE GEOLOGY AND GEOPHYSICS

Bathymetry. (Mr. Dunkle, Miss Helen Hays, Mrs. Grace Witzell, and Mrs. Lynne Senefelder).
(Contract Nonr-4029)

During this period three Cruise Navigation Reports went to press: ATLANTIS 280 - 281, WHOI Ref. No. 62-42; BEAR 280, WHOI Ref. No. 63-11; CHAIN 28, WHOI Ref. No. 63-14.

The Flow Camera continued to copy PGR records of echo soundings bringing the total of cruises on 35 mm film up to 68. The period between May 1 and July 31 was used for THRESHER analysis and the making of expanded copies of bottom photos for this analysis.

Frequency Distributions in Submarine Topography (Mr. Mizula).
(Contract Nonr-3243)

The frequency distribution analysis of some measurable characteristics of ocean bottom topography was continued with an aim toward completing this phase of the work. The topographic characteristics under analysis are: steepness of bottom slopes, slope lengths, curvatures, (rate of change of slope), and depths. The data are measurements made on the echo-sounding records from two crossings of the Central North Atlantic Ocean; one running West to East between 30° and 40° North latitude, and the other from Southwest to Northeast between 32° and 58° North latitude.

The frequency distributions of these variables had previously been determined for each of the two oceanic profiles. In addition, parts of the profiles across different types of bottom topography such as the Continental Slope or Rise, or the mid Atlantic Ridge were examined separately. The average slope, slope length, and curvature was determined for 60 such parts of these two profiles and the distribution of these average values was analyzed. The mean values of curvature ranged from less than 0.02 to about 8 degrees per mile. There was a conspicuous absence of values, however, between 0.7 and 1.7 degrees per mile and a concentration of points just above this interval.

During the period, 30 additional divisions of the two Atlantic profiles were analyzed. This was done both in an attempt to resolve the peculiarity in the distribution of mean curvatures and to obtain more numerical information on the irregularity of the bottom profile in different parts of the ocean. The new profile sections were obtained by sub-dividing some of the previously analyzed longer portions of the profile, particularly those having an average curvature falling near the limits of this "blank" interval. Two-way frequency distributions slope vs slope length from some of these sections were also analyzed. Computation or estimation of the means and variances of frequency distributions that now number close to 300 were completed. A report is in preparation.

Bottom Reverberation (Mr. Hall and Dr. de Witte).
(Contract Nonr-4029)

Charts showing the location of all explosive shot measurements applicable to reverberation analysis have been completed. Using data from 12 cruises from 1954 to 1962, approximately 3400 shots at 125 locations in the North and South Atlantic Oceans and the Norwegian and Mediterranean Seas are available for analysis. Approximately 4% of these shots, from 37 locations, have been partially analyzed with the Electronics Associates Oceanographic Computer to obtain an energy spectral density with time. Some preliminary analyses of back-scattering coefficients vs angle of incidence have been made, but results from this analysis are as yet incomplete pending final selection of models from which backscattering coefficients may be obtained.

Analysis using analog-to-digital conversion of the shot data and digital calculations of backscattering coefficients with time is anticipated. Energy spectral density calculations after Arons (1954) and Weston (1960) are being converted to the metric system in line with the recent Intergovernmental Oceanographic Commission resolution, and a program to obtain spectra for small charges at moderate depths has been written for the GE 225 Computer.

Arons, A. B., 1954. Underwater Explosions Shock Wave Parameters at Large Distances from the Charge. Journal of Acoustical Society of America, Vol. 26, No. 3, pp. 343-346.

Weston, D. E., 1960. Underwater Explosions as Acoustic Sources. Proceeding of the Physical Society, Vol. LXXVI, p. 233.

Reverberation as an acoustical interference phenomenon was investigated during the summer at the Woods Hole Oceanographic Institution by Dr. de Witte of the University of Illinois. From this work we hope that a more fruitful model of bottom reverberation will emerge. At present the theory of optical reflection from imperfect mirrors appears a promising aid.

Seismic Reflections over the Abyssal Hills Southeast of Bermuda (Miss Bunce). (Contract Nonr-4029)

CHAIN Cruise #39 was organized to reconnoiter the region of the Abyssal Hills southeast of Bermuda. Geophysical observations included continuous echo-sounding, gravity measurements, continuous seismic profiling over selected areas using the 100,000-joule spark source, heat flow measurements, and dredge-camera studies. Two small regions were studied in some detail: (1) between 24° and 25°N latitude and 55° and 56°W longitude; (2) between 29°N and 30°N latitude and 59°30'W and 60°30'W longitude.

Reflection information obtained with the profiler was used to determine locations for dredging and photographing the bottom during the cruise. In addition, a profile was made from the Abyssal Hills (area 2 above) onto the Bermuda Rise to study the transition between the two regions and to correlate these reflection data with previous reflection and refraction profiles on the Rise.

Seismic Reflection Studies Southeast of Martha's Vineyard (Mr. Caulfield, Mr. Horner, and Mr. Hoskins). (Contract Nonr-4029)

During the summer of 1963 analyses were made of a seismic profile taken on CHAIN Cruise #29. This profile runs approximately south to north across the break of the Continental Shelf starting at a depth of 1800 fathoms and finishing at a depth of 50 fathoms. The 25,000-joule spark source and a single hydrophone were used to make these records. Figure 1 presents an example.

The analysis consisted of identifying and tracing the lateral extent of the sub-bottom reflection events and the presentation of them on an adjusted scale, and studying the frequency absorption and reflection characteristics of the sub-bottom in this particular area.

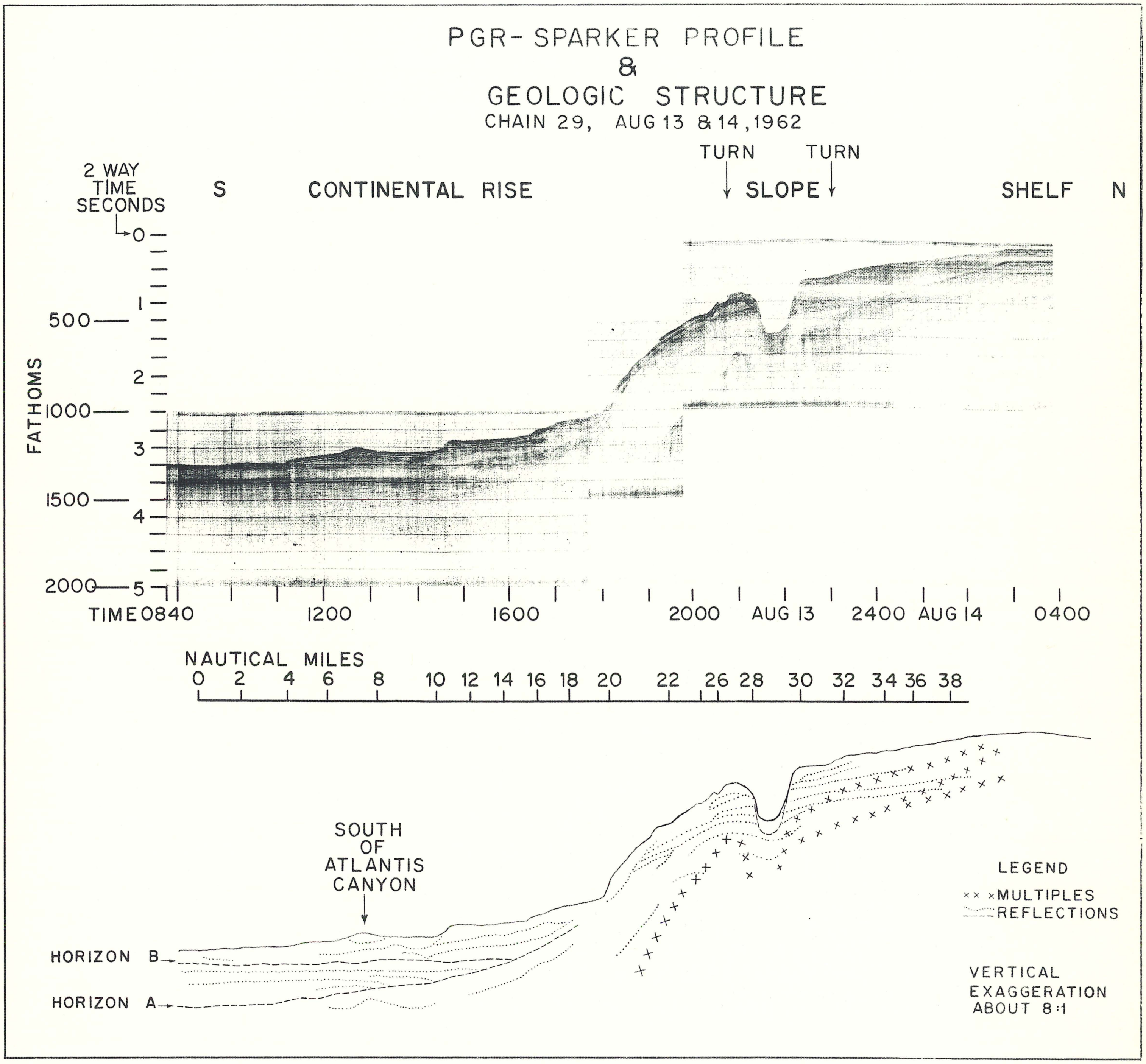


Figure 1 PGR Record of Seismic Reflection Profile Southeast of Martha's Vineyard.

Additional reflection profiles were made in this same area on CHAIN Cruise #39. These records were the first made with the augmented detection system which included a five-element towed hydrophone array, the matched filter correlation system, and the 100,000-joule underwater spark source. These records are being examined with the same objectives as for the CHAIN #29 observations just mentioned above.

Seismic Signal Processing Techniques (Mr. Caulfield and Mr. Nowak).
(Contract Nonr-4029)

A detailed study done over the last year on the frequency spectrum of the sparker pulse has lead to the development of a matched filter detection system for improving the signal-to-noise ratio of the receiving system and hence gaining greater penetration. This system improves the signal-to-noise ratio by at least eight to one. The system at present is designed for maximum penetration rather than high resolution. The frequency response is from 15 cps to 150 cps. This system obtains the cross-correlation function of the return signal with an approximate model of the outgoing signal. It discriminates against signals that do not have the same frequency components and phase relationships as the initial outgoing signal hence improving the signal-to-noise ratio of the receiving system.

The output of the correlator is basically the convolution integral of the incoming signal with a model of the outgoing signal after it has passed through a band-pass filter similar to that used in the receiver. The output signal is squared, and sent into a signal level discriminator. The output of the discriminator is amplified and displayed on a Precision Graphic Recorder. A typical record (Fig. 2) shows dark bands, each of which represents one sub-bottom return. This record was made southwest of Martha's Vineyard on a southerly course. Maximum penetration is more than double that obtained with standard techniques.

It is planned that in the next year two improved models of this device will be built, one for shipboard operation and one for land-based analysis. The energy of the output of the correlator is directly proportional to the actual energy in the return signal. Hence, this opens up a means to study with greater accuracy, because of the better signal-to-noise ratio, the energy contained in each sub-bottom reflection. Also varying the parameters of the matched filter may enable one to obtain the characteristic transfer function of a given sub-bottom layer, providing more information about the actual structure of the sub-bottom.

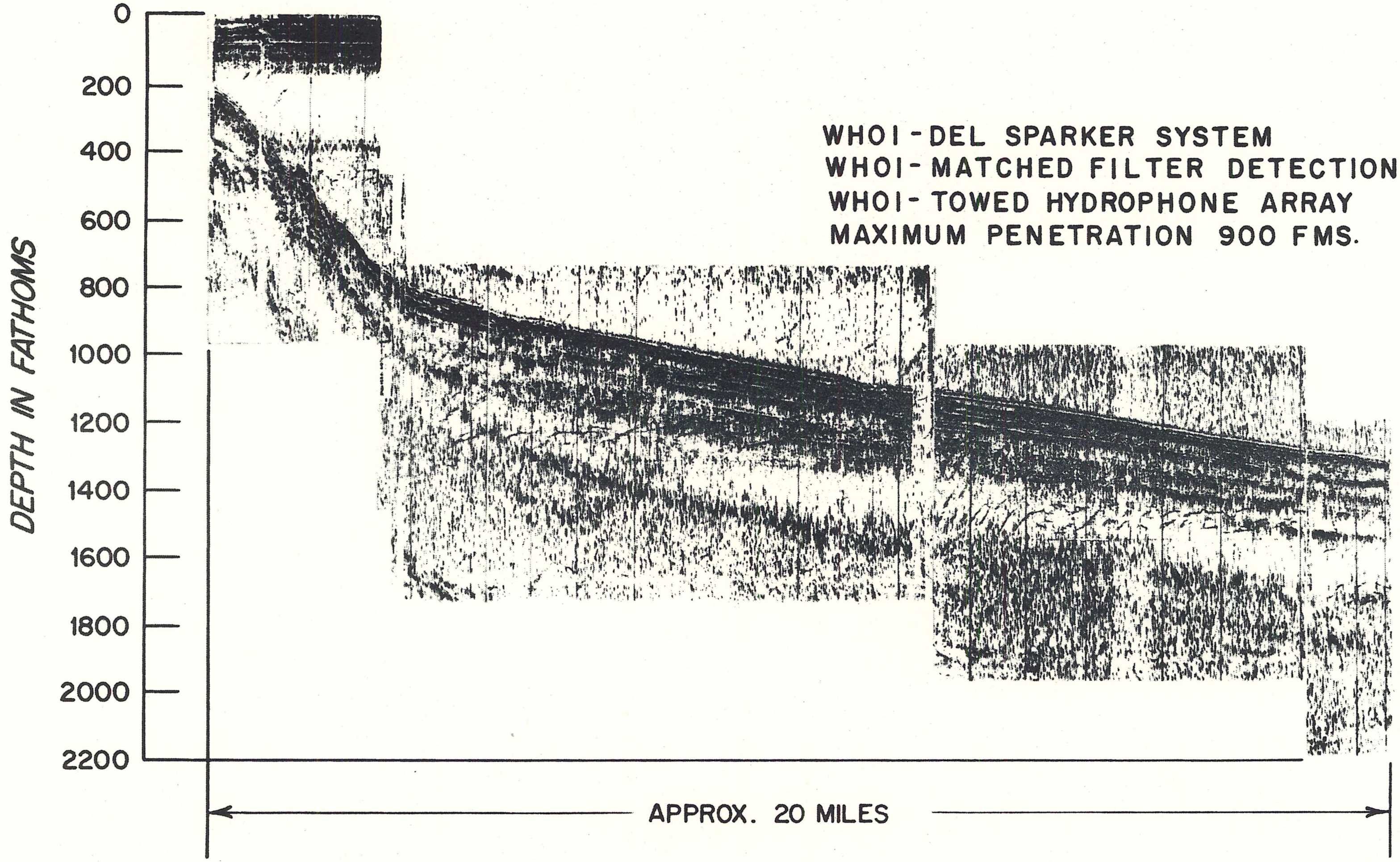


Figure 2 PGR Record of Matched Filter Detection System used in Seismic Signal Processing.

Gravity Program (Dr. Bowin).
(Contract Nonr-4029)

Experience gained with LaCoste and Romberg sea gravity meter #13 during the last year and a half is giving us considerable confidence in this meter and its ability to measure the gravity field to within about 3 to 4 milligals in the open ocean under calm to moderate sea condition. The main source of error is not in the gravity sensing instrumentation but in the determination of the ground speed of the ship. In the future we expect to approach a solution to this problem by experimenting with both inertial navigation systems and with deep-towed speed logs.

Our advances in the automation of sampling and reduction of gravity data are tied very closely with improvements in our shipboard data processing system described in another section of this report. Of particular note here is the automatic real-time plotting of gravity profiles along with bathymetric and magnetic profiles by means of a digital plotter. Also, the new computer facility will allow computer control of stepping motors which will automatically adjust the spring tension in the gravity meter so as to more fully automate the collection of gravity measurements, and, more importantly, to increase the accuracy of the measurements and the percentage of time during which valid gravity measurements are made.

A program for the IBM 7090 computer to update the navigation and gravity values obtained in real-time and preserved on paper tape is practically complete. This programming effort, under subcontract to IBM, Federal Systems Division, was a great deal more complicated than presumed. This effort was complicated, not by the computations, but by a variety of types of incorrect values contained in the real-time data. Types of errors include operator errors and malfunctions of the real-time clock.

The experience gained from this effort has given a greater understanding of real-time operations and has led to modifications in the shipboard program which will be incorporated in the new system to be sea tested during November - December, 1963.

During the past contract period plans have been completed for the forthcoming cruise of the R/V CHAIN during November - December 1963. The purpose of this cruise will be to investigate the geologic relations between the Puerto Rico trench, Bahama platform, Caribbean island arc, Beata ridge, and the Caribbean sea. Continuous gravity measurements will be particularly aimed at helping to define the offshore extent of significant structures known from geologic and gravity studies on the island of Hispaniola. These studies have shown the distribution of two adjacent parts of the Earth's crust whose tectonic behaviors were quite different during Tertiary time. The region encompassed by the eastern third of the Dominican Republic, and eastward to Puerto Rico, has remained relatively stable since Eocene time. To the west, however, strong faulting and crustal warping have been active through the Tertiary and appear to be continuing today. An object of the proposed investigations will be to attempt to determine the extent of these two types of crust away from where they are exposed on land. The submarine Beata ridge, which divides the Caribbean Sea into two basins, may be related to the junction of the two types of crust found under Hispaniola.

Magnetics Program (Dr. Bowin, Mr. Nowak, and Mr. Caulfield).
(Contract Nonr-4029)

The construction of two proton precession magnetometer fishes has been subcontracted with Ocean Research Engineering, Inc., and these fishes are complete except for cable connections. We are experiencing delays from Brand-Rex Corporation, which contracted to build four buoyant towing cables with pre-stressed dacron strength members. In order to guarantee a magnetics program on the forthcoming cruise of the R/V CHAIN, this delay has necessitated the obtaining of a substitute made of DSS3 cable from another company around which a braid of stainless 310 is to be wrapped to act as a strength member

Magnetic information will be sampled automatically by the ship-board data processing system (described in another section of this report) from the digital counter display of the frequency of precession. This method of entry of magnetic data into the computer is expected to be significantly superior to the method used during CHAIN Cruise #34 when the required computer hardware was not available for direct sampling of a digital counter.

Profiles of magnetic field intensity will be plotted in real-time on a digital plotter along with bathymetric and gravity profiles. This capability should greatly enhance the ability to interpret and check the magnetometer values during the course of the cruise.

Heat Flow Measurements (Dr. Reitzel and Mr. Halunen).
(Contract Nonr-4029)

Heat flow measurements made previously in the southwestern North Atlantic have been analyzed and published (WHOI Contribution No. 1396).

In August and September five heat flow measurements were made southeast of Bermuda as part of CHAIN Cruise #39. Preliminary calculations indicate the average heat flow was 1.00×10^{-6} cal/cm^2 sec. The lowest value, 0.62×10^{-6} cal/cm^2 sec. was measured approximately 650 miles southeast of Bermuda. Northwestward the heat flow values increased to 1.33×10^{-6} cal/cm^2 sec. at approximately 170 miles southeast of Bermuda.

Preparations are now being made for making heat flow measurements on CHAIN Cruise #41 to the Caribbean area and CHAIN Cruise #43 to the Indian Ocean.

Rock Dredging (Dr. Chase and Mr. Feden).
(Contract Nonr-4029)

In September 1962, during Cruise #39 eight dredge hauls were made in the region of the Abyssal Hills southeast of Bermuda. Six of the hauls were made with a Nalwalk modified rock dredge; a Nalwalk triangular rock dredge and a twelve-inch pipe dredge were used from the remaining hauls. Four of the dredge lowerings were with camera. In addition, one lowering was made with camera only.

The pipe dredge haul (CH #39-D4, Station 6) yielded about one hundred pounds of red clay. Very similar red clay was recovered from a plastic sampler taped to the bale of the rock dredge on each of the other hauls.

About two pounds of manganese nodules were recovered in one of the rock dredge hauls (CH #39-CD8, Station 14). Some of the nodules contained nuclei of altered basaltic rock up to two inches long. X-ray diffraction studies of these nuclei have been made.

Underwater Photography (Mr. Johnston, Mr. Allen, and Mrs. Gallagher). (Contract Nonr-4029)

Approximately one and one-half months of the period reported upon were spent at sea in an effort to locate the submarine THRESHER. Many photographs of debris were taken. Camera configuration during this period was of two types. (1) A free-running system towed along predetermined tracks and (2) a deck-controlled system that could be actuated from the ship's laboratory where "suspect" targets were revealed on the Precision Graphic Recorder.

A special camera rig was constructed for use in Bermuda to record the bottom prior to the dredge pick-up of bottom samples. This rig hung on the towing cable several hundred feet ahead of the dredge itself and was free running.

A program is presently underway to prepare mosaics from negatives of the THRESHER search now on file. All films are being edited and those showing adequate overlap or edge pinning proportion are printed out as 8 1/2" x 11" glossy prints. Standard procedures are used, i.e., feather-edging and overlap to produce a primary uncontrolled mosaic. Stringent methods to control scale are not used because the exact height of the camera above bottom in not known.

At present 37 one hundred-foot rolls have been edited to produce partial mosaics. Missing "shots" however, due to camera misfire, sudden swings, and/or slow movement across the bottom seldom present more than six or seven matching prints at one time.

Normal darkroom work has continued with completion of file copies of standard size prints (8 1/2" x 11") of various lowerings from the THRESHER search. Five hundred feet of undeveloped film has been processed, and dry mounting of prints for a reproduction master for publication has been done.

Maintenance and overhaul of two camera units, two "strobe" light units, and one "pinger" unit has been completed. These units were partially flooded when dragged along the bottom subsequent to a towing winch failure. Salt water corrosion in the electrical circuitry made complete rebuilding necessary.

Normal cleaning inspection and inventory of photographic gear on hand has been made.

Preparations are being made to insure that adequate and reliable gear will be available for the forth-coming Indian Ocean and Mediterranean Sea cruise. A portable self-contained darkroom is being built into a Helio-hut. This will permit rapid deck installation of a self-sufficient darkroom on any vessel employed without sacrificing normally scarce internal laboratory space.

The following tabulation summarizes work accomplished in printing and mounting stereo pairs of photographic prints from bottom photographs taken during various cruises.

Cruise	Lowering		
CHAIN #7	EC 1 & 2	36 single	
	EC 4	67 pairs 38 single	Mediterranean
			&
	EC 8	53 pairs 6 single	Atlantic
	EC 11	63 pairs	
	EC 12	122 pairs	
	EC 13	91 pairs 2 single	
	EC 14	94 pairs 103 single	

Some lowerings in this group had already been done but more pictures were found on the film. It was sometimes necessary to reprint one side due to size difference.

Cruise	Lowering		
ATLANTIS #266	22	462 vertical 355 oblique	Blake Plateau
	23	420 vertical 284 oblique	
	25	363 vertical 270 oblique	
ATLANTIS #280	1	101 pairs	San Pablo Peak
	2	100 pairs	San Pablo Annex
	3	148 pairs 4 single	Manning Peak
	4	36 pairs 21 single	Rehoboth Seamount
	5	22 pairs 21 single	Abyssal Plain
	6	206 pairs 113 single	Kelnir East Peak

Above pictures mounted and catalogued.

Total prints mounted during this period:

1, 103 pairs

2, 498 single

The vertical and oblique pictures were considered single for inventory purposes although they were mounted on the same card whenever possible. They are not stereo pairs. Total now in files;

21, 652 pairs
9, 319 single

The miscellaneous enlargements have been added to the collection.

OCEANOGRAPHIC AND ACOUSTIC INSTRUMENTATION

Instrumentation for THRESHER Survey

Deep-Anchored Acoustic-Buoy Navigation System (Mr. Dow).
(Contract Nonr-4029)

One of the major difficulties encountered during the search for the submarine THRESHER was the inability to navigate as closely as required.

Since no radio navigational data, even Decca and Loran C, could be relied upon to give positions better than one eighth of a mile at best, attempts were made to navigate from anchored taut wire buoys equipped with radar reflectors or transponders. It was found that because of the great length of line required to anchor these buoys in deep water they could move within a circle of a mile or so in radius around their original position depending on the wind and current. It was therefore decided to try anchoring a radio acoustic buoy near the THRESHER search area. The buoy's hydrophone would be tied quite close to the anchor so that its movement would be limited to fifty feet or less. The survey ship would then echo-range to this deep hydrophone using the sparker or boomer as a pulsed sound source. The sound pulses picked up by the hydrophone would be wired to the surface buoy and transmitted via radio back to the ship where they would be displayed on a Precision Graphic Recorder. Since the same recorder would also key the sound source, a synchronized record would be obtained, and the time delay between transmitted and received pulses could then be read directly from the recorder chart. As this delay would be essentially the ship-to-hydrophone acoustic travel time through the water, ranges to the hydrophone could be readily determined.

Of course, the absolute position of the anchored hydrophone can still be determined only approximately, using Decca, Loran C, or other navigational aid. In practice, this would be done by steaming in patterns around the position, sparking, measuring acoustic travel times, and taking simultaneous Decca fixes, until the geographic location is determined as closely as possible. However, despite ambiguity in this determination, the ship-to-hydrophone range could always be measured accurately so that with two or more such buoys in position, a consistent grid of the area could be made.

Because of ship schedules, only a very short time could be devoted to preparation for an experimental operation near the THRESHER search area. Therefore, it was necessary to use cables and equipment on hand, keep new construction to a minimum, and call in an outside firm, Oceanographic Research and Equipment Company of Vineyard Haven, Massachusetts to assist in assembling the system and anchoring it at sea.

The final assembly is shown in Figure 3. The operations command (CTG 89.2) had placed a 1500 lb. weight limit on anchors in the area, so that the bathyscaphe TRIESTE could lift them in case it should become entangled in the mooring lines. This made it necessary to use an anchor which was too light considering the currents in the area and the buoyancy of the system. As a result the anchor finally was dragged into deep water so terminating the experiment. However, the operation of the system was successful during its short life and can, with suitable alteration, be made into a useful instrument, not only for pin-point navigation, but also for submarine seismology. A description of operations with the buoy is given below.

The buoy assembly having been planted, the ship steamed away on a range run at about 4 knots with the sparker operating the ship. The buoy transmitted the sound arrivals from the deep hydrophone back to the ship where they were recorded on the Precision Graphic Recorder as well as on magnetic tape. During the run, sub-bottom reflections ranging between 425 and 3025 meters were also observed. Figure 4 shows a PGR recording of this run, illustrating the clarity of the received signal and precision with which travel times can be determined. At about 1 1/4 miles the ship reversed course passing within a quarter mile of the buoy and continued on out to a range of 6 1/4 miles. At this range and about 11 hours after the

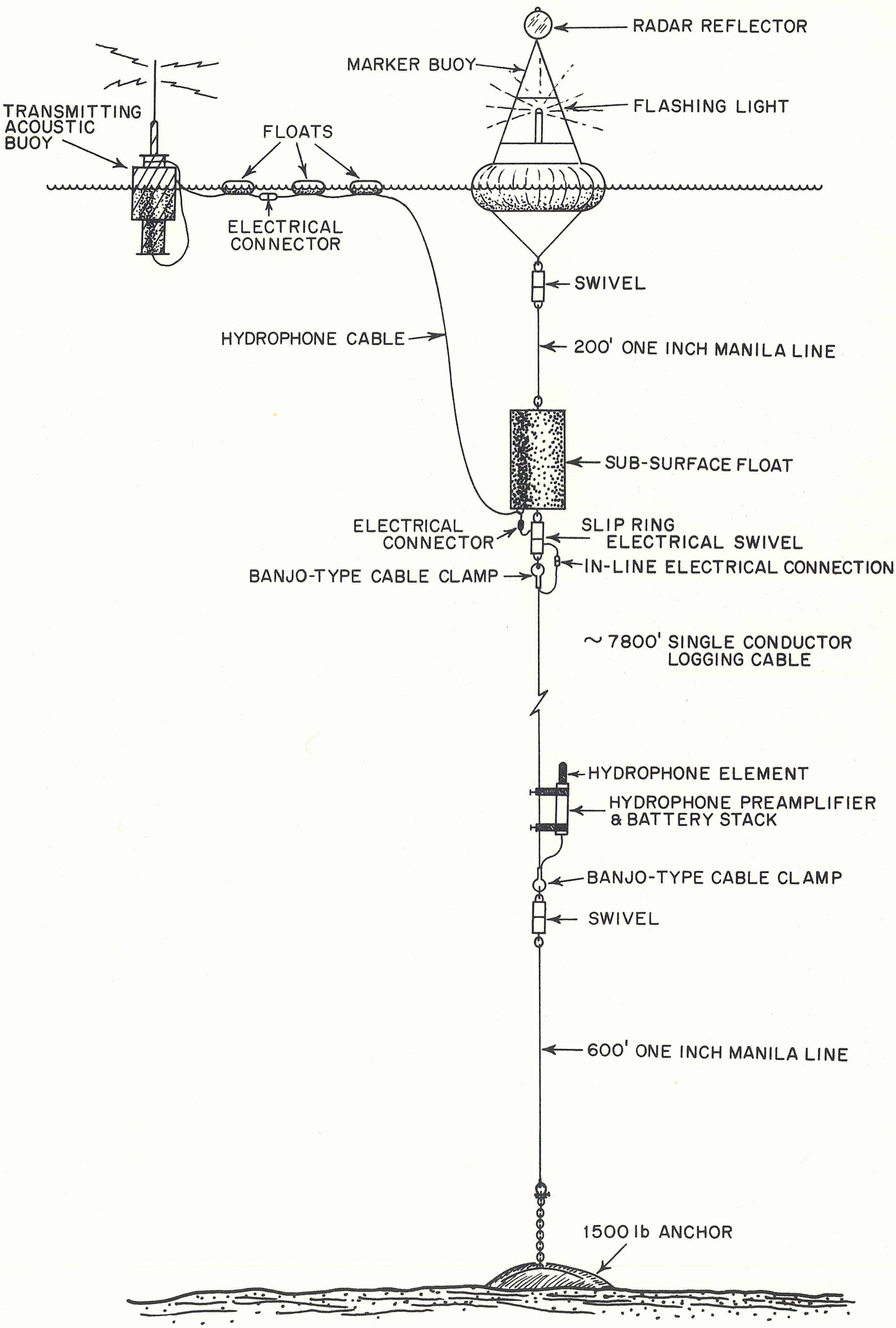


Figure 3 Final Assembly of Deep-Anchored Acoustic Buoy.

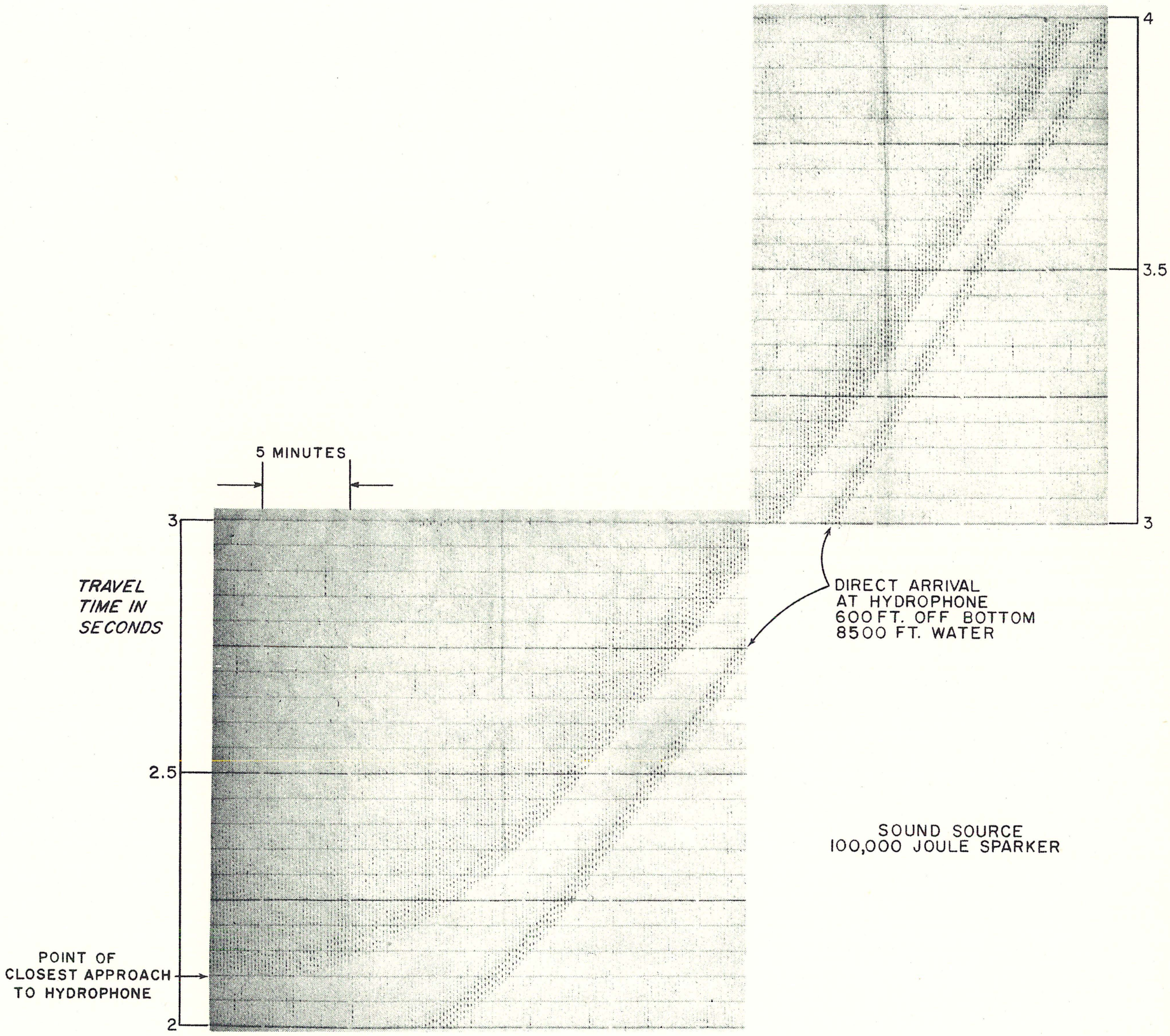


Figure 4 PGR Record of Run using Deep-Anchored Acoustic-Buoy Navigation System.

beginning of the operation the buoy hydrophone started to become noisy and the ship returned to the buoy to locate the trouble. A check on the position of the buoy revealed that the strong currents in the area had caused the anchor to drag several miles into deeper water and the entire system was now afloat and moving rapidly. Consequently, it was decided to retrieve the gear by essentially reversing the anchoring process. Apparently little damage had been done despite the shocks and strain to which the system must have been subjected during the anchor dragging. When all of the logging cable had been reeled in, inspection revealed that the deep hydrophone and the preamplifier were still operating properly when they reached the deck.

The above is considered significant because it indicated the following:

1. Given time and opportunity to select proper hydrophone cable and anchor, and other components, a completely successful mooring of this type of system in deep water can undoubtedly be made using cheap, single-conductor, well-logging cable.

2. The system operates successfully as a precision navigation aid for detailed examination of a small area of the bottom in deep water. Previous sea trials have shown the maximum radio range of the buoy on other occasions to be in excess of 75 miles in the daytime.

3. The system has great potential for application to marine seismology as well as navigation.

<u>Echo Ranging Fish</u> (Mr. Dow).
(Contract Nonr-4029)

The Inverted Echo Sounder described in WHOI Ref. No. 63-6 and various progress reports has been principally used to date as a precision depth-measuring device. The sounder consists of a high-power, short-pulse 12 kc transmitter, or pinger, which is beamed continually toward the surface as it is being lowered. The surface-reflected pulse is returned to the deep instrument where it is detected by a deep receiver, and telemetered via a single-conductor logging cable back to the surface vessel, where a Precision Graphic Recorder is used for readout. The deep instrument is self-contained and battery-operated. It has been used successfully for several years in conjunction with our sound velocity program in determining the depth of velocimeters attached to it; it has been lowered to more than 18, 000 feet in the ocean.

When the Institution assisted in the search for the submarine THRESHER it was decided that a deep echo-ranger, which could operate close to the bottom in 8, 000 feet of water and be towed by a surface vessel, would be extremely useful as a search tool to guide underwater cameras to targets which appeared to be of interest. Consequently, a framework was quickly assembled in the form of a crude fish with two large fins for keeping the unit aligned in the direction of tow. On this frame the Inverted Echo Sounder described above was mounted, but it was placed in a horizontal rather than vertical position so that it would serve as an echo-ranging system. Two strip cameras were also mounted on the frame together with strobe lights for illuminating the bottom. A system was arranged which made it possible to turn the cameras on and off at will from the surface, so that the film would be conserved during the lowering of equipment. Once at depth, the direct and bottom-reflected pings from a vertical side lobe on the deep transducer provided a means of determining the height of the gear above the bottom, so that the rig could then be lowered or raised to bring the camera into proper focus.

The performance of the Inverted Echo Sounder as an echo-ranging device was useful throughout the THRESHER search. It was able to detect the presence of small objects on the bottom at a range up to 400 yards or more. Debris believed to be from the THRESHER was first located and photographed with this equipment.

Unfortunately, in June, the underwater vehicle complete with echo-ranger, cameras and a potential detecting device was lost over the side in deep water due to failure of a cable termination. It is planned to replace the lost gear with an improved fish, as described in ENCL. (B) of the Renewal Proposal for Contract Nonr-4029, dated July 9, 1963, which would be an extremely valuable tool for submarine geology and other uses. However, this program must be postponed temporarily until the lost Inverted Echo Sounder is replaced, since we now have only the original experimental model and this is presently seeing extensive use in the Indian Ocean. The Inverted Echo Sounder has been partly assembled and is now being wired. This unit can be used as a production prototype. Care has been taken to use as many standard components and structural members as possible to keep costs down.

A Light-Weight Towed Transducer for Use in Triangulation Systems (Mr. Hess).
(Contract Nonr-4029)

A transducer-carrying fish which is easily fabricated and shows excellent towing characteristics was developed during the THRESHER search. Originally made as a field expedient, the fish has been towed from outriggers to obtain bearing data on pinger equipped dredges, cameras, etc.

The fish consists of an EDO Type X-20100 transducer affixed to a body made of two pieces of "Dexion" construction material about 32" in length (Figure 5). The tail assembly consists of a 6" x 6" x .062" aluminum vertical stabilizer and a 14" x 6" x .062" aluminum horizontal stabilizer. The tow point is readily moved for balancing purposes as the "Dexion" has a large number of holes along its length which will accept a 1/4" shackle.

The fish has been towed at speeds up to 11 knots with no detectable direction instability observed. The broadband noise due to towing is not objectionable up to about 6 knots. If the transducer is tuned it is probable that the maximum towing speed may be increased.

The transducer is designed for operation at 12 kc/s and is used to receive short 12 kc/s "pings" from another towed instrument. An array consisting of two fish towed from outriggers and one hull-mounted transducer provides the necessary information for calculating the bearing of the other towed system. The cost of the fish, excluding the transducer is under ten dollars.

Shipboard Data Processing System (Dr. Bowin).
(Contract Nonr-4029)

From July 1962 to September 1963 we have operated a digital computer (IBM 1710 Mod 1) aboard the R/V CHAIN. This program was a cooperative effort with the International Business Machines Corporation to design, build, test, and make operational an automatic shipboard system for the acquisition and reduction of gravity, navigation, and ocean depth information in real-time. This system makes gravity anomaly values

Figure 5 Light-Weight Transducer-Carrying Fish.

available for interpretation, planning, and checking purposes aboard the ship while the cruise is in progress.

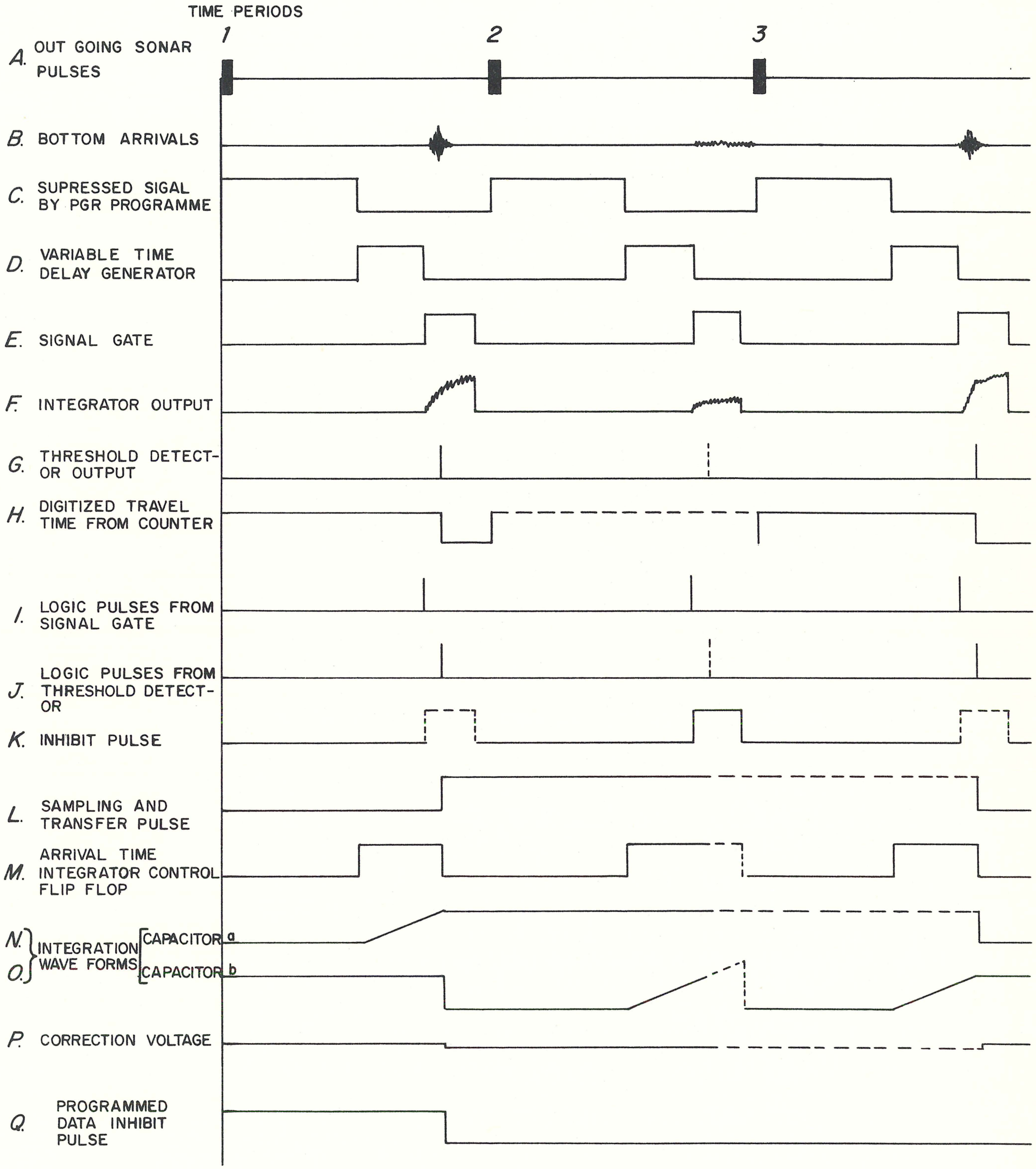
The presence of the shipboard computer facility on CHAIN made it possible to develop and run computer programs during CHAIN Cruise #38 in search for the missing submarine THRESHER. These programs were used in tracking deep-towed instruments searching the sea bottom for the THRESHER.

Experience gained with this shipboard system has lead to further developments and improvements which are presently being implemented under another contract with International Business Machines Corporation. A new, expended, and improved shipboard data processing system will allow computer feedback control and remote display of information; on-line automatic digital plotting of bathymetric, gravity, and magnetic profiles; time-sharing of real time and off-line computer programs; utilization of removable random-access magnetic disk storage packs; and three remote input-output typewriters will be used in experiments for improving the collection, dissemination, and availability of the scientific and navigational information logged during the course of a cruise.

<u>Automatic Digital Travel-Time Measurement</u> (Mr. Wilharm).
(Contract Nonr-4029)

The following design of the automatic acoustic travel time indicator (WHOI Ref. No. 63-27, p. 12) was completed and tested on CHAIN Cruise #39 with the exception of the logic and automatic time delay circuitry. Logic and automatic time delay circuits are being added to prevent errors in travel time data from being transmitted to the IBM 1710 computer input and to provide automatic tracking of the bottom echo.

An explanation of the system is as follows. References are made to the functional diagram in Figures 6 and 7.



NOTE: SOLID LINES INDICATE NORMAL STATES OF OPERATION
BROKEN LINES INDICATE ALTERNATE STATES OF OPERATION

Figure 6 Time Base Diagrams of the Automatic Digital Travel-Time Measurement System.

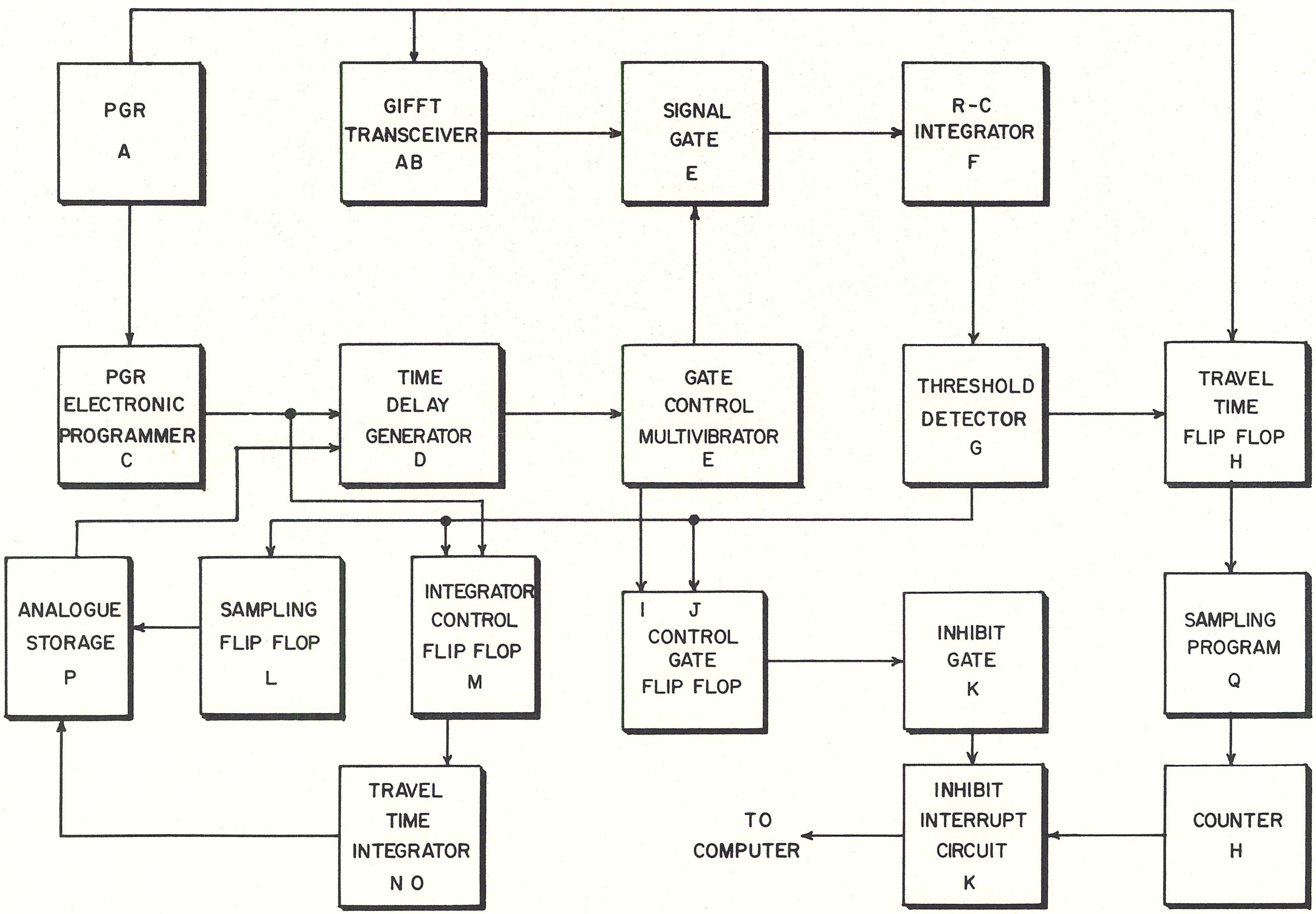


Figure 7 Block Diagram of Automatic Digital Travel-Time Measurement System.

Time Period 1

A. A pulse is transmitted from a sonar transceiver at zero time.

B. A bottom reflection is received.

C. Also beginning at zero time the PGR Electronic Programmer (WHOI Ref. No. 63-27, p. 11) has started counting a predetermined time interval. This is used to program out unwanted bottom echoes, scattering echo layers, etc.

D. The PGR Programmer triggers the voltage controlled time delay generator. This unit may be adjusted to a preset time interval to cause the gate to open just before the bottom arrival.

E. The signal gate will open allowing the bottom echo (B) to pass through at the proper time.

F. The bottom echo is then amplified and integrated to help detection and suppress unwanted noise.

G. A threshold voltage detector circuit which may be adjusted will emit a pulse when the integral has reached the predetermined voltage level.

H. The travel time flip flop which was on at zero time is then turned off upon arrival of the threshold pulse, thus controlling the counter.

Then skipping to:

Q. The output of the travel time flip flop is, however, fed before going to the counter, through a sampling programmer which will allow data to flow at even slower rates to fit the computer gravity program, e. e., samples at once a minute in shallow water.

Returning now to:

H. Travel time, is then counted, digitized, and sent to the computer.

I. A logic pulse is obtained from the leading edge of the signal gate control multivibrator (E) to be used with ....

J. A logic pulse from the threshold detector to generate ....

K. An inhibit pulse when only one of the signal gate pulse (I) and not the threshold detector logic pulse (J) is present. In Time Period Two when the threshold detector logic pulse does not appear, the inhibit pulse appears and stops data from flowing to the computer program.

L. An automatic means for controlling the time delay generator (D) is being provided by further logic. A sampling and transfer flip flop is triggered by the threshold detector to control the sampling rate and the alternate storage of an analog voltage to be used to sense the proper time of arrival of succeeding echoes. In Time Period Two where the threshold detector pulse did not appear the circuit logically remained at the same level which corresponds to the previous bottom arrival (N).

M. The arrival time integrator control flip flop is turned on from the leading edge of the time delay generator pulse and turned off by the arrival of the threshold detector pulse. In case of a weak bottom arrival, and no threshold detector pulse, Time Period Two, it is turned off by the trailing edge of the signal gate pulse. Note that in Time Period Two, line O, the integral (the charge on capacitor b) is returned to zero volts because the signal gate has turned off the arrival time integrator flip flop.

N. The travel time integrator has the function of storing a voltage at a linear rate which is directly proportional to the arrival time of the bottom echo. A dual storage is used so that most recent data can be compared to the last previous. In the event that there is no threshold detector pulse or bottom arrival, such as in Time Period Two, the voltage level of the appropriate storage capacitor will remain in its original state.

P. A correction voltage derived from the difference between successive alternate arrival time integration voltages and proportional to the successive change in bottom echo arrival times is then fed back to the time delay generator (D) to automatically compensate the time delayed control of the signal gate.

This system has been designed to be in most cases compatible with bathymetry and gross bottom reflectivity programming. The signal gate can act as a gate for reflectivity and the logic programming for computer input.

Spark Sound Sources (Mr. Caulfield).
(Contract Nonr-4029)

During May and June a 100,000-joule general purpose energy source was constructed. This new system has the capability of driving either a sparker transducer or an electromechanical transducer (EG & G Boomer).

One of the primary difficulties with the early sparkers was the failure of the capacitor banks. The Del Electronics Corporation has supplied us with a set of newly designed capacitor banks. These new capacitors have proved to be many more times reliable than the older set. The system at full energy has a repetition rate of one per ten seconds. When used as a sparker sound source the output power is in the frequency range from 10 cycles per second to 5,000 per second with a peak pressure of approximately 135 db re 1 dyne/cm^2. This new system has an automatic control panel and is designed with an interlock system and failure indicator for complete safety and ease of maintenance.

The new system operated on CHAIN Cruises #37, #38, and #39. During these cruises the system reliability was very good and the system cycled over 133,000 times. During these cruises a new brass electrode design was decided upon and with this, electrode life has approached 37,000 discharges before failure or need of replacement. Quick change electrodes have been employed. During the first leg of CHAIN Cruise #39, many calibrations and pressure-time curves were made to analyze the effects of changing depth and operating energies on the acoustic pulse shape. Small deviations of pulse shape were noted from shot to shot. It was extremely rewarding to find from these measurements that our theory for predicting the initial pulse shape for a given system operating in the ranges from 500 to 100, 000 joules is correct. The results for the initial pulse of the 100, 000-joule source were well within 5% of the predicted shape.

During the coming year the sound source will be re-packaged for easier maintenance and will be mounted, if time allows, in a portable van for moving on and off the ships.

<u>Oceanographic Computer</u> (Mr. Coleman).
(Contract Nonr-4029)

The four Electronics Associates Incorporated Oceanographic Computer Groups, Model 4.038, have undergone complete operational checks during the past six months. Corrective maintenance has been performed where required by WHOI technicians and an E. A. I. engineer, who, in September, corrected a number of problems related to the D. C. amplifiers.

Three of the four groups are presently complete. (SN-1, SN-6, SN-7). Group SN-7 is equipped with "gain" and "integration constant" read-out adaptors for IBM use. Adaptors for all other units are available, but not yet installed. Group SN-3 has been used to supply the need for individual computer units. It has not been modified in any way, and can be returned to original service condition by returning 45.001 units and 10.067 power supplies to the racks.

Where an entire computer group is deemed impractical or not necessary, two individual units are now available; two more are planned. The units are comprised of one 45.001 computer, one 10.067 power supply; one WHOI built read-out panel with input, output and monitor jacks; and one specially constructed cable harness.

A single unit may be conveniently mounted in a conventional 28-inch relay rack (half rack) using specially designed mounting adaptors for computer and power supply. Space is available at the top of the rack to mount an oscilloscope for monitoring purposes. This arrangement has proved to be a practical and neat set-up, particularly for shipboard operation. The entire unit can be adjusted in the laboratory and then placed aboard ship without further attention except for input and output plugs.

Chronic failure of power transformers in the 20.458 Limit and Storage Indicators has been corrected. Additional μ-500 diodes and a current limiting resistor have been installed in all units; and no further problems have been experienced with the Limit and Storage Indicators.

Suitcase Amplifiers (Mr. Dow).
(Contract Nonr-4029)

The seven Suitcase amplifiers, originally designed and constructed in 1950 for general-purpose underwater listening in the frequency range from 5 cps to 50 kcps have been used on practically every cruise of this department for thirteen years. They are now practically worn out and must be replaced. A survey of the market indicates that the Suitcase is still unique with respect to that combination of features which make it adaptable to all phases of our listening programs. Consequently, design of the unit has been modified in accordance with modern electronic techniques which, among other advantages, permit a five-channel amplifier to occupy the same overall volume as the former two-channel unit. The revised instrument will also be adaptable for operation with line hydrophone arrays. An experimental version of the new amplifier is under construction. When this unit has been satisfactorily completed, a prototype will be constructed suitable for loan to a commercial outfit for production in whatever quantity is desired.

Radio Buoys (Mr. Dow).

Modifications of our three radio-acoustic buoys allow longer battery life for continuous operation. The efficiency and power output of the R. F. transmitters have also been increased.

<u>Precision Graphic Recorder</u> (Mr. Witzell and Mr. Nowak).
(Contract Nonr-4029)

The PGR recording paper must maintain a certain dampness to print legibly all wanted signals at any of the sweep and paper transport speeds. Many recordings are now taken at slow sweep speeds (2.5 to 7.5 sec.) and slow paper feeds (256 to 384 lines to the inch). Both of these factors make the preventing of drying much more difficult, especially in locations where heating is great. When the paper dries the operator has to interrupt the recording and pull out fresh wet paper.

On CHAIN Cruise #39, the problem was solved partially by introducing forced warm moist air into a tube with a series of small holes jetted in the direction of intersection of the helix drum and blade electrode. This improvement was extremely beneficial, but the physical dimensions of the tube and its location obstructed the operator's view of the recording.

Recently many experiments, involving the introduction of warm moist air into other compartments of the recorder, have proven to be unsuccessful with the exception of the area below the recording paper in the helix cradle box where the air is jetted up and toward the paper and helix interface. Care must be exercised to insure that too much moisture is not introduced.

<u>A Dynamic Signal Mixer</u> (Mr. Dimock).
(Contract Nonr-4029)

This unit was designed to facilitate the mixing of two to five signals without the attenuation and low input impedance normally associated with static mixers. Its first use has been with the five-detector array.

The input to any of the five channels is either a cathode follower or an inverting amplifier as selected by a front panel switch. The input impedance is maintained at 500 K ohms in both cases and the gain of the inverting amplifier is adjusted to be equal to that of the cathode follower. The inverting amplifier is used only when the attendant 180° phase shift is required, being inserted ahead of the cathode follower. The cathode follower drives a second cathode follower through a 600-ohm Daven attenuator, the mixing taking place in the output of the second cathode follower. The attenuator provides calibrated gain settings for each channel. The mixed output, taken from the common cathode resistor of the five "second stage" cathode followers, feeds an amplifier whose gain is adjusted to give a gain of 0 db to this point. The signal divides at this point and goes to two conventional triode amplifiers having gains preset to 20 db. A Daven 250 K-ohm attenuator is provided in each amplifier giving calibrated output control referred to a single input from +20 db to -20 db. Each of these amplifiers feeds a cathode follower providing a 600-ohm output impedance. The unit has a self-contained power supply requirin 115V AC with the power line switch, fuse, and pilot light on the front panel.

This instrument provides five input channels with 500 K-ohms input impedance, 180° phase shifting in each channel if desired, and a dynamic range of better than 60 db with input limit of 6V peak to peak. The mixed output is available from two completely independent 600-ohm jacks each with its own 40-db attenuator.

Reliable Utility Audio Amplifier (The Crown Monitor) (Mr. Dimock). (Contract Nonr-4029)

This instrument was originally designed to facilitate the monitoring of magnetic tape recordings. However, since the original design was completed many additional applications for a general purpose amplifier have appeared and a redesign of this instrument was required to improve its versatility.

The current model of this instrument has an input impedance of 250 ohms and a total of 80 db input attenuation, 40 db in a Daven 2 db/step attenuator and a 40-db pad. The preamplifier is a four-stage triode amplifier employing a large amount of negative feedback for stability and noise reduction purposes. These tubes are shock-mounted, low-noise types and have DC-operated filaments. A two-tube phase inverter is used, with a chassis-mounted potentiometer for balancing, the output of which feeds two cathode followers and a class A_1 transformer-coupled power amplifier. The cathode followers provide two low-impedance outputs, 600 ohms each, of opposite phase, while the transformer-coupled amplifier provides power to drive the self-contained speaker and permits, from a separate transformer secondary, a 4-ohm output. The internal gain to the two 600-ohm outputs and the 4-ohm output is internally set to 60 db providing overall gains from -20 db to +60 db by front panel control. A pad-type volume control is used with the speaker and is across the output line provided for external speaker use. The internal speaker is disconnected when an external one is used.

A maximum bandwidth, high impedance loading on the 600-ohm output, of 5 cps to 200 kcps is available with up to 15V peak-to-peak. Distortion of less than 1/4 of 1% is easily obtained and the internal noise referred to the input is less than 8μV.

The instrument requires 115V AC power and has a power switch and pilot light on the front panel. Fuse protection is provided with the holder located on the rear of the chassis.

A Frequency Multiplier and Divider for 30, 60, 120, 240, 480-Cps Time Bases

(Mr. Dimock).
(Contract Nonr-4029)

A frequency multiplier and divider was designed to facilitate the playback of magnetic tapes to the Precision Graphic Recorder when the playback speed and record speed are different. The time-base frequency is normally recorded on one channel of the tape and is used as the input signal to this device. Analysis time when playing back is reduced by high tape speeds and sub-divided time base signals.

The instrument in its present form consists of five input channels to accommodate frequencies of 30 cps, 60 cps, 120 cps, 240 cps, and 480 cps. The signal into any of these, except the 480-cps one, is first clipped at approximately 300 millivolts and then fed into a tuned amplifier. The amplifier output is then full-wave rectified and fed, via the next input jack (all of which are switching types), to the next clipper and amplifier. The 480-cps input is fed to a Schmitt trigger circuit after clipping and amplification, then to a binary divider, and then to the 240-cps stage via the switching jack. All inputs are first brought to 240 cps, which is one of output frequencies required by the PGR for Scale lines, and then reduced to 60 cps, by means of two binary dividers. The 240 cps input is available at the front panel at two parallel jacks while the 60 cps input is present through two transformer-coupled amplifiers. Level controls are provided for both 60 cps outputs. A relay-controlled 60 cps power source is available at the front panel and is energized only when an input is present. The power output here is not precisely 60 cps but is line frequency only and provides for stopping the tape recorder if for some reason the signal on the tape is not continuous.

The unit has about 50 db of dynamic range for any input, the minimum input being approximately 60 millivolts. No change in output level will occur between these input limits. The bandwidth of any input is 4 cps. No output is available outside of these bandwidths.

Transducer Modifications (Mr. Dow, Mr. Sutcliffe, Mr. Stillman, and Mr. Shultz).
(Contract Nonr-4029)

Many EDO type X20100 transducers are used by us in the echo-location pingers for cameras, dredges, corers, etc., the inverted echo sounders and receiving systems for echo location. Originally provided by EDO from designs by H. Edgerton, the high voltage terminals were extremely vulnerable to mechanical and electrical damage. A program to modify some thirty of these transducers is about one quarter completed.

The electrical feed-throughs of the earlier design are being removed and their holes are used for evacuating and filling the modified transducers. New feed throughs have been re-located. The crystal array has been rotated to shorten internal leads and provide more clearance for electrical insulation. High voltage, high pressure (20,000 psi) Mecca receptacles (#1849-2049) are being used and their mating plugs provided on associated equipment. Figure 8 shows original connections and the modified connectors. Figure 9 shows method of refilling the transducers with D. B. oil.

Transducers (Mr. Witzell and Mr. Presberg).
(Contract Nonr-4029)

Three reconditioned EDO UQN-1 transducers from the U. S. Navy Transducer Facility, Boston Naval Yard are being installed on the R/V CHAIN. One was required at the "starboard hull" position and the other two in the bow. One-sixteenth-inch-thick stainless steel acoustic windows, similar in shape to a Chinese coolie hat, have been placed over the bow transducers. The stainless steel protects the rubber diaphragm of the transducer from the high dynamic pressures caused by the ship's motion.

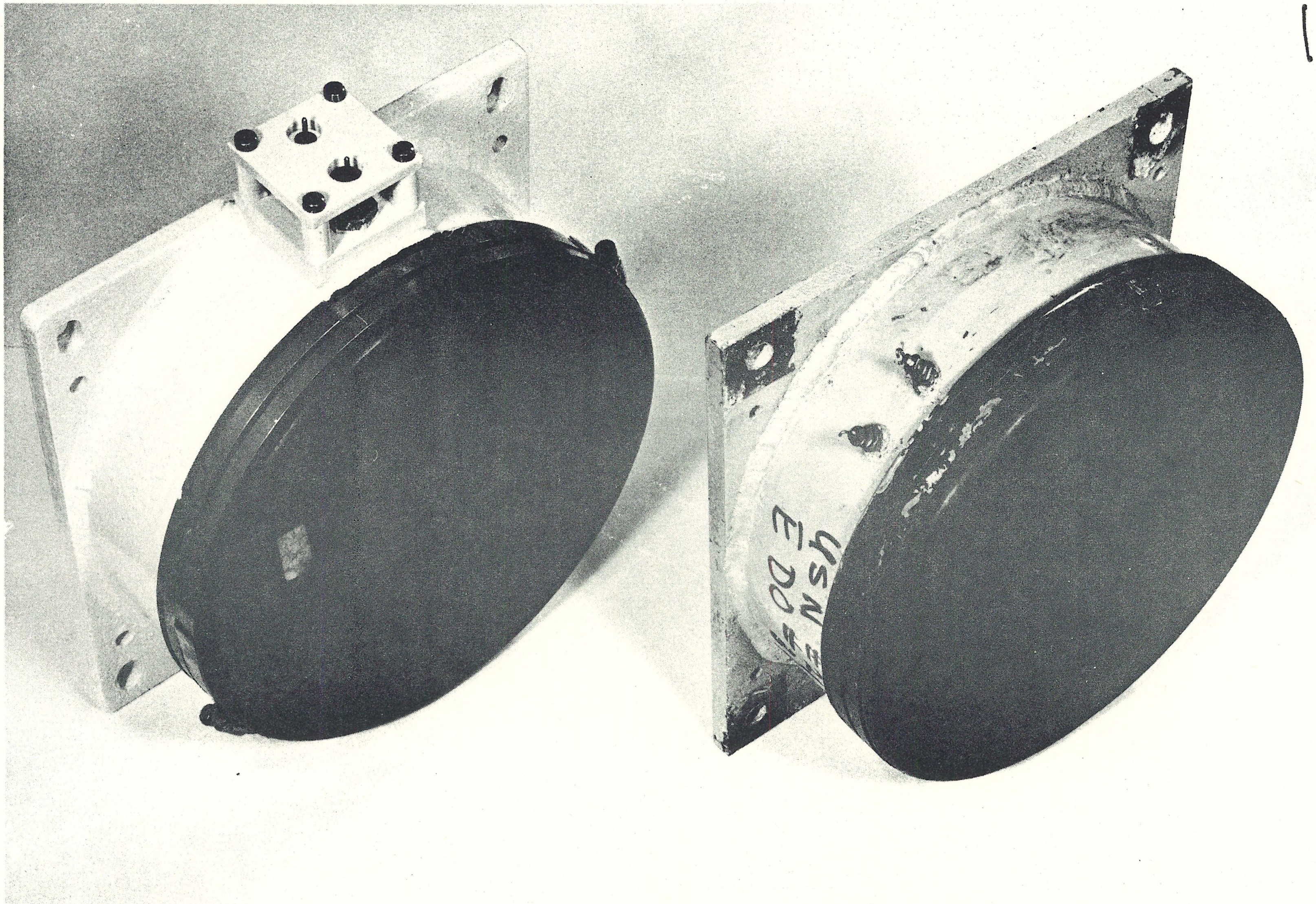


Figure 8 Original and Modified Camera-Pinger Transducer Connectors.

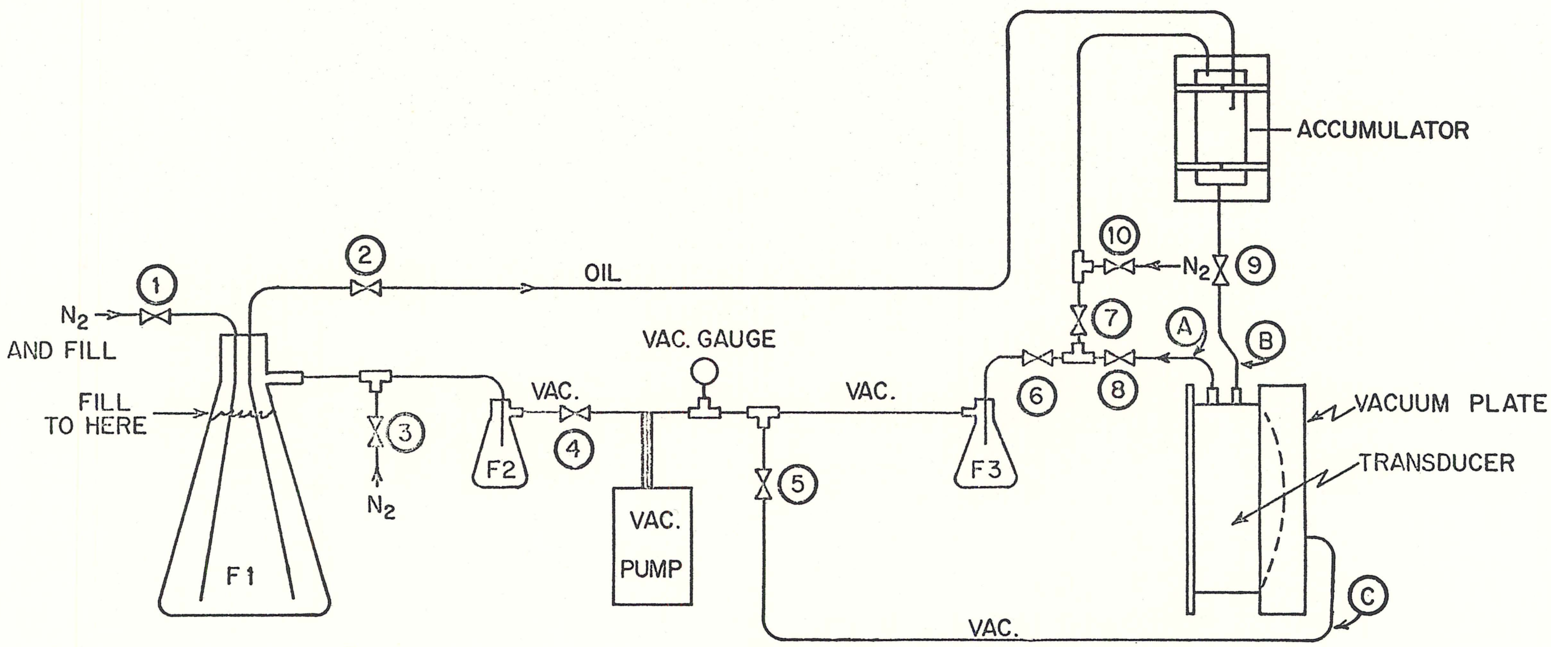


Figure 9 Flow Diagram of Method of Refilling Camera-Pinger Transducers.

Previous installations of the acoustic "windows" met with mechanical failure because the screw-fastenings which were inserted into the wooden frame surrounding the transducers eventually loosened and broke free. Now the windows are fastened to a metal ring which surrounds the transducer, an installation which should be mechanically strong.

Shear Pin Weak Link Assembly (Mr. Hess).
(Contract Nonr-4029)

A weak-link assembly has been designed for placing in a cable system to release any dragged device when the strain exceeds a predetermined value (Figure 10). This is useful for releasing dredges which have become caught in the bottom. By shifting the tow point to the rear of the dredge, it may often be retrieved.

The release range of the weak link is adjustable from approximately 600 lbs. to over 5000 lbs. by proper choice of shear pin material and size. Provision is made for pins of .125", .187" and .250" diameter. The holder is fabricated from 17-4 P.H. stainless steel which is corrosion resistant and strong.

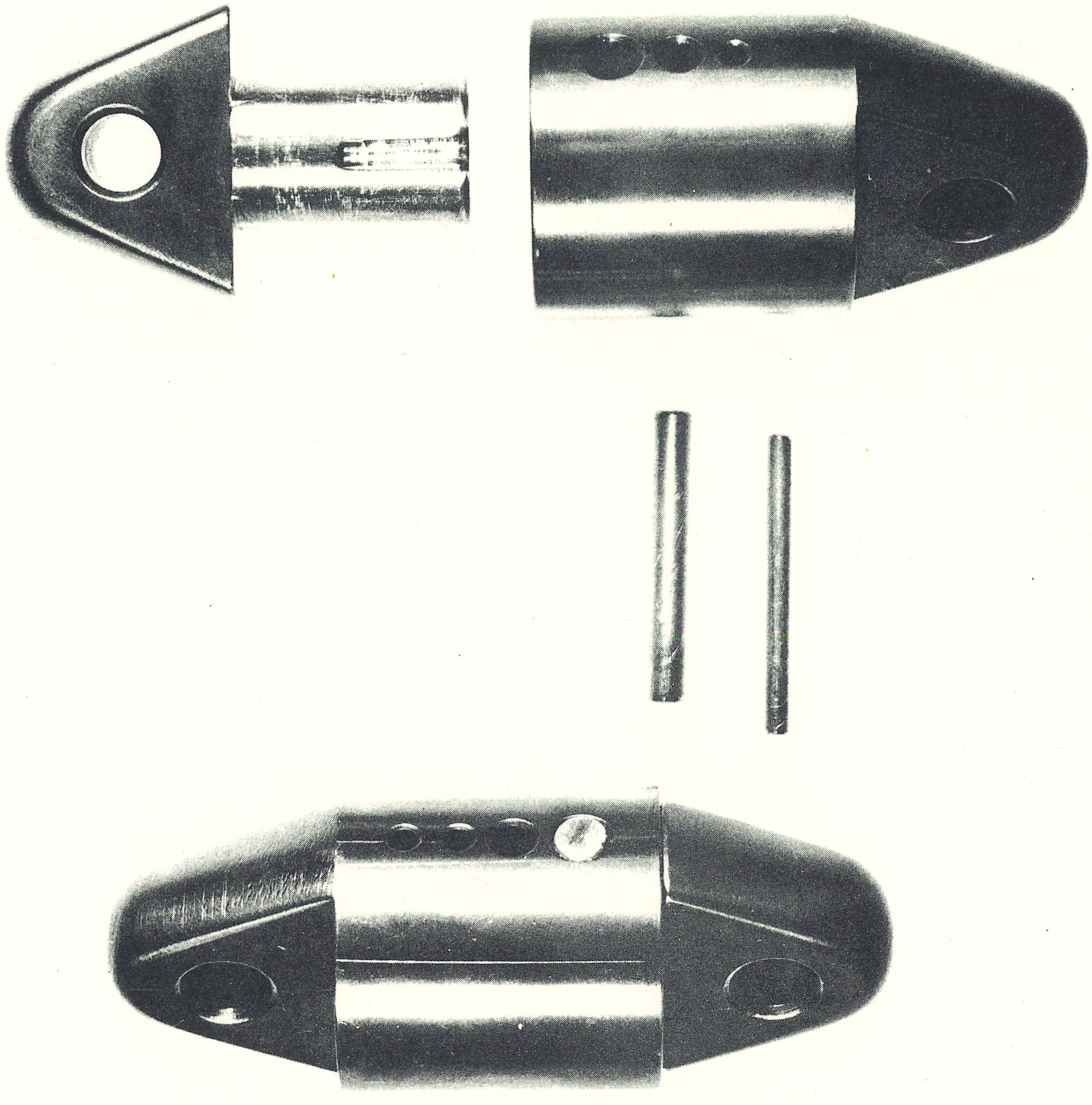


Figure 10 Shear Pin Weak Link Assembly.

APPENDIX

Use of Vessels

Operation of ATLANTIS during this period was as follows:

Cruise No.	Departure Return	Work Area	Principal Investigation	Scientist in Charge
293	1-3 July 1963	Continental Shelf Block Island Martha's Vineyard	Bottom photography, testing equipment	F. Hess

Operation of the R/V CHAIN during this period was as follows:

39	28 Aug. 1963 23 Sept. 1963	North Atlantic Ocean Bermuda Area	Continuous Seismic Profiling, Bottom photography, heat probe measurements, dredge hauls, gravity measurements.	D. Caulfield E. T. Bunce

Operation of the R/V ATLANTIS II during this period was as follows:

2	11-18 April 1963	THRESHER Area	THRESHER Survey	S. T. Knott
3	21-27 April 1963	THRESHER Area	THRESHER Survey	J. B. Hersey
5	2-15 May 1963	THRESHER Area	THRESHER Survey	E. E. Hays
6	21-27 May 1963	THRESHER Area	THRESHER Survey	S. T. Knott

Visitors' List

W. H. Healey	Alden Electronics
C. B. Officer	Alpine Geophysical Associates
P. A. Sutton	" " "
C. A. Burke	AMSOC National Academy of Sciences
E. L. Chatterton	American Bosch Arma Corp.
J. J. Stimson	" " " "

Visitors' List (contd)

Dr. de Kaush	American Machine & Foundry
A. L. Lane	" " "
V. Sabella	Anderson Power Products
M. Ligor	Applied Measurements
W. G. Sykes	Arthur D. Little Company
F. Bupp	Astrapower Inc.
P. J. Clifford	Avco Corp.
E. J. Curtiss	"
C. P. Glover	"
D. Heard	"
J. F. Holmes	"
W. J. Porter	"
B. Shapiro	Bell Telephone Labs. - Whippany, N. J.
H. Soloman	" " " " "
C. Easterly	Benthos Company
S. O. Raymond	" "
R. Cower	Boston Insulated Wire
W. E. Garne	" " "
M. J. Daintith	British Admiralty Underwater Weapons Establishment
A. L. Farrell	California Computer Products, Inc.
M. Hill	Cambridge University, England
C. B. Lister	" " "
C. J. Long	Charles Walsh Associates
S. G. Lemon	Chesapeake Instrument Corp.

Visitors' List (contd)

J. E. Nafe	Columbia University
R. L. Rather	Commercial Engineering Corp.
L. Penseen	Concord Electric Controls
H. J. De Giovanna	Del Electronics Inc.
H. Darine	Deutsch Co.
C. Frankenberger	" "
J. H. Anderson	Edgerton, Germeshausen & Grier
H. E. Edgerton	" " "
W. A. Kearsley	" " "
J. P. McCarthy	" " "
J. J. McInnis	" " "
R. A. Saunders	" " "
C. Warner	" " "
R. Ballingall	Electronic Associates Inc.
W. G. Campbell	Francis Associates
H. de Lauze	France, Bathyscape Labs.
G. Jobert	France, Institut de Physics du Globe
C. H. Bowser	General Atronics
K. F. Worley	Gerber Scientific Instruments Co.
S. M. Simpson	Gruscian Company
J. W. Swordstrom	Hazeltine Corp.
R. A. Frosch	Hudson Laboratories
J. H. Shields	Hughes Aircraft Co.

Visitors' List (contd)

R. L. Haedrich	Museum of Comparative Zoology, Harvard Ur
Marie P. Fish	Narragansett Marine Lab. - URI
D. Krause	" " " "
P. J. Perkins	" " " "
W. L. Petrie	National Academy of Sciences - NRC
A. I. Haines	National Bureau of Standards
Prof. S. Austin	Northeastern University
Prof. V. Benson	" "
R. B. Abel	Office of Naval Research (ICO)
Lcdr. F. A. Edwards	" " "
Lcdr. W. W. Lasley	" " "
A. E. Maxwell	" " "
T. D. Pfundsten	" " "
Cdr. R. A. Spenser	" " "
R. E. Fisher	Ocean Research Equipment Inc.
D. B. Foster	" " " "
D. H. Frantz	" " " "
R. G. Fleagh	Office of Science & Technology
J. R. Hartens	Reynolds International Inc.
C. F. Grice	Schlumberger Well Surveying Corp.
J. D. Isaacs	Scripps Institution of Oceanography
G. G. Shor	" " "
I. E. Wallen	Smithsonian Institution
P. Cohen	Sperry Gyroscope Company
W. Horowitz	" " "
D. Jackson	" " "

Visitors' List (cont)

T. H. Gifft	T. H. Gifft & Associates
R. DeSteffany	Tektronix Inc.
E. M. Fine	U. S. Department of Defense
J. M. George	" "
W. A. Smith	" "
S. Tucker	U. S. Department of State
S. Van Brush	U. S. Department of Commerce
G. B. Farquhar	U. S. Naval Oceanographic Office
K. W. Kaye	" "
A. Molloy	" "
R. Nekritz	" "
H. B. Stewart	U. S. Coast & Geodetic Survey
J. A. Roche	U. S. Steel Corp.
M. B. Dobrin	United Geophysical Corp.
J. C. Steinberg	University of Miami
M. A. Komertz	Wyman Gordon Company

Personnel

J. B. Hersey	Geophysicist
T. R. Stetson	Project Coordinator
A. C. Vine	Physical Oceanographer
A. D. Voorhis	Physicist
W. Dow	Electronic Engineer

Personnel (contd)

Bowin, C. O.	Research Assoc. in Geology
Graham, J. W.	" "
Baxter, L.	Research Assoc. in Physics
Bunce, Elizabeth	" "
Knott, S. T.	Research Assoc. in Engineering
Caulfield, D. D.	Research Assistant in Physics
Ruppert, G. N.	" "
Bohlen, W. F.	Research Assistant in Engineering
Cain, H. A.	
Carter, A. L.	" "
Dimock, A. D.	" "
Hess, F.	" "
Johnston, A. T.	" "
Martin, B. M.	" "
Nowak, R. T.	" "
Stillman, S. L.	" "
Sutcliffe, T. O.	" "
Wilharm, L.	" "
Witzell, W. E.	" "
Coleman, V. E.	Research Assistant in Electronics
Bennett, L. C.	Research Assistant in Geophysics
Birch, F.	" "
Fahlquist, D. A.	" "
Hall, J. K.	" "
Presberg, D. L.	" "
Reitzel, J. S.	" "
Nalwalk, A. J.	Research Assistant in Geology
Feden, R. H.	" "
Halunen, J.	" "
Bergstrom, S. W.	Res. Assistant in Underwater Acoustics
Dunkle, W. M.	" "

Allen, R. W.	Technician	
Broughton, Jane	"	
Dugan, E. F.	"	
Gallagher, Gloria	"	
Grant, C.	"	
Hays, Helen	"	
Johnson, Dianne	"	
Lynch, F. L.	"	
Mathews, Barbara	"	
Nafe, Mary	"	
Riegel, R.	"	
Senefelder, Lynne	"	
Soderland, Carol	"	
Witzell, Grace	"	
Morehouse, C. B.	Electrical Technician	
Broadbent, Alice	Secretary	
Cleary, Kathleen	"	
Mellor, Florence	"	
Nolan, Judith	"	
Rhoads, Sandra	"	
Breslau, L. R.	Pre-Doctoral Student Investigator, MIT	
Chase, R. L.	Post Doctoral Fellowship	
Bacigalupo, V.	Cooperative Student -	Northeastern Univ.
Clough, J. W.	"	"
de Rivera, R. L.	"	"
Leonard, P. D.	"	"
Merna, J. E.	"	"
Perlman, D.	"	Antioch College
Pratt, B. C.	"	Northeastern Univ.

Summer Personnel

de Witte, A.	Visiting Professor - Univ. of Illinois
Elsasser, W.	" Princeton Univ.
Horner, W.	Visiting Teacher - Fountain Valley School, Colorado Springs, Colorado
Hoskins, H.	Visiting Investigator - Univ. of Chicago

WHOI Fellowship

Doutt, J. A.
Smythe, R. T.
Yates, M.

Students

Cotter, R. J.
Doyle, A.
Geary, R. B.
Gillette, Deborah
Hodgkins, H.
Knox, R. A.
Kuenzler, H. W.
Neilson, G. W.
Olmsted, C.
Scott, R.
Wooding, F. B.

DISTRIBUTION LIST
WHOI REF. NO. 63 - 42

Bell Telephone Laboratories, Inc. Whippany, New Jersey Attn: C. F. Wiebusch, Div. 54	1
Chief Bureau of Ships Department of the Navy Washington 25, D. C. Attn: Code 335	1
Code 341	1
Code 631	1
Code 689B	1
Oceanographer (RU222) Bureau of Naval Weapons Department of the Navy Washington 25, D. C.	1
Director Hudson Laboratories 145 Palisade Street Dobbs Ferry, New York	1
Oceanographer U. S. Naval Oceanographic Office Washington 25, D. C.	2
Director Lamont Geological Observatory Torrey Cliff Palisades, New York	1
Systems Analysis Group Undersea Warfare Research and Development Council Room 5-224 U. S. Naval Ordnance Laboratory White Oak Silver Spring, Maryland	1

Bureau of Naval Weapons
Department of the Navy
Washington 25, D. C. 1

Office of Naval Research
Department of the Navy
Washington 25, D. C.
Attn: Code 468 1
Code 416 1
Code 418 1
Code 466 1

Director
Defense Research Laboratory
University of Texas
Austin, Texas 1

Commander
Submarine Development Group TWO
c/o Fleet Post Office
New York, New York 1

Director
Department of Oceanography
Texas A and M College
College Station, Texas 1

Director
Marine Laboratory
University of Miami
1 Rickenbacker Causeway
Virginia Key
Miami 49, Florida 1

Director
Narragansett Marine Laboratory
University of Rhode Island
Kingston, Rhode Island 1

Librarian
U. S. Naval Postgraduate School
Monterey, California 1

U. S. Naval Ordnance Test Station
Pasadena Annex
3202 East Foothill Boulevard
Pasadena 8, California
Attn: Pasadena Annex Library 1

Commander (Code 753)
U. S. Naval Ordnance Test Station
China Lake, California 1
Attn: Technical Library

Commanding Officer
U. S. Naval Underwater Ordnance Station
Newport, Rhode Island 1

Office of Naval Research
Project Officer
U. S. Navy Sofar Station
APO 856
c/o Postmaster, New York 1

Office of Naval Research
495 Summer Street
Boston, Massachusetts 1

Commanding Officer
U. S. Navy Mine Defense Laboratory
Panama City, Florida 1

Air Force Missile Test Center
Technical Library, MU-135
Patrick Air Force Base, Florida 1

U. S. Navy Research Laboratory
Washington, D. C.
Attn: Code 2021 1
Code 5500 1
Code 5510 1

Commanding Officer and Director U. S. Navy Underwater Sound Laboratory Fort Trumbull New London, Connecticut	2
Commanding Officer U. S. Naval Ordnance Laboratory White Oak, Silver Spring Maryland	2
Commanding Officer and Director (Code 560) David Taylor Model Basin Washington 25, D. C.	2
Applied Physics Laboratory University of Washington 1013 East 40th Street Seattle 5, Washington	1
Director U. S. Naval Air Development Center Johnsville, Pennsylvania	1
Force ASW Officer Commander, Submarine Force U. S. Pacific Fleet c/o Fleet Post Office San Francisco, California	1
Anti-Submarine Defense Force U. S. Atlantic Fleet U. S. Naval Base Norfolk 11, Virginia	1
National Academy of Sciences National Research Council 2101 Constitution Avenue Washington, D. C.	1

ONR Liaison Officer Woods Hole Oceanographic Institution Woods Hole, Massachusetts	1
Department of Geology University of Wisconsin Madison 6, Wisconsin	1
Daystrom Electric Division of Daystrom, Inc. 753 Main Street Poughkeepsie, New York	1
Fluid and Solid Mechanics Laboratory Institute of Science and Technology Post Office Box 618 Ann Arbor, Michigan	1
Ordnance Research Laboratory Pennsylvania State University University Park, Pennsylvania	1
Commanding Officer and Director ASW Tactical School U. S. Atlantic Fleet Norfolk, Virginia	1
Commanding Officer and Director U. S. Navy Electronics Laboratory San Diego 52, California	2
Director Marine Physical Laboratory of the Scripps Institution of Oceanography San Diego 52, California	1
Anti-Submarine Warfare Research Center La Spezia, Italy	1

Commander
Destroyer Development Group TWO
c/o Fleet Post Office
New York, New York 1

Commander Destroyer Flotilla THREE
c/o Fleet Post Office
San Francisco, California 1

Commanding Officer
Anti-Submarine Defense Force
U. S. Pacific Fleet
Fleet Post Office
San Francisco, California 1

Institute for Defense Analyses
Communications Research Division
Von Neumann Hall
Princeton, New Jersey 1

Pacific Oceanographic Group
Nanaimo, British Columbia 1

Armed Services Technical Information Agency
Arlington Hall
Arlington 12, Virginia 10

Chief of Naval Operations
Op-07T
Washington 25, D. C. 1

Chief of Naval Operations (Op03EG)
Department of the Navy
Washington 25, D. C. 1

Seyir ve Hidrografi Dairesi
Cubuklu-Istanbul, Turkey
Via: ONR Branch Office, London 1

National Institution of Oceanography
Wormley, Godalming, Surrey, England
Attn: Library 1

Advanced Research Projects Agencies
Pentagon
Washington 25, D. C.
Attn: Nuclear Test Detection Office 1

Director
Bureau of Commercial Fisheries
Biological Laboratory
Woods Hole, Massachusetts 1

U. S. Naval Applied Science Laboratory
(Code 9360)
Naval Base
Brooklyn 1, New York 1

Woods Hole Oceanographic Institution
Reference No. 63-42

OCEANOGRAPHIC AND UNDERWATER ACOUSTICS RESEARCH, conducted during the period 1 May - 31 October 1963, 40 pp. November 1963.

Unclassified

This is a report of the research program under contracts Nonr-4029 (1 May - 31 October 1963), and Nonr-3243 (1 May - 31 October 1963). Both contracts are with the Office of Naval Research, Code 466. Contract Nonr-4029 is a continuation of Contract Nonr-1367.

Under Contract Nonr-4029, ATLANTIS II and CHAIN, in May and August, were employed in searching for the sunken submarine THRESHER by various means. Under the same contract, activities were devoted also to the development of systems or components of systems for search and for navigational control required in such operations. One system of submerged navigation was employed for locating suspended instruments by acoustic ranging from the ship. A second navigation system was also tested which depends on acoustic ranging either from the ship or from the suspended instrument to a hydrophone buoyed near the bottom. This hydrophone is connected to a radio link in a surface buoy. This system will be useful not only for navigation but also for bottom reflection studies. A program has been started to print and mount all photos taken by WHOI on the THRESHER search; it will be coordinated with other similar efforts in the continuing investigation of the disaster.

1. Progress Report
2. ATLANTIS II
3. CHAIN
4. THRESHER

1. Woods Hole Oceanographic Institution

This card is UNCLASSIFIED

Woods Hole Oceanographic Institution
Reference No. 63-42

OCEANOGRAPHIC AND UNDERWATER ACOUSTICS RESEARCH, conducted during the period 1 May - 31 October 1963, 40 pp. November 1963.

Unclassified

This is a report of the research program under contracts Nonr-4029 (1 May - 31 October 1963), and Nonr-3243 (1 May - 31 October 1963). Both contracts are with the Office of Naval Research, Code 466. Contract Nonr-4029 is a continuation of Contract Nonr-1367.

Under Contract Nonr-4029, ATLANTIS II and CHAIN, in May and August, were employed in searching for the sunken submarine THRESHER by various means. Under the same contract, activities were devoted also to the development of systems or components of systems for search and for navigational control required in such operations. One system of submerged navigation was employed for locating suspended instruments by acoustic ranging from the ship. A second navigation system was also tested which depends on acoustic ranging either from the ship or from the suspended instrument to a hydrophone buoyed near the bottom. This hydrophone is connected to a radio link in a surface buoy. This system will be useful not only for navigation but also for bottom reflection studies. A program has been started to print and mount all photos taken by WHOI on the THRESHER search; it will be coordinated with other similar efforts in the continuing investigation of the disaster.

1. Progress Report
2. ATLANTIS II
3. CHAIN
4. THRESHER

1. Woods Hole Oceanographic Institution

This card is UNCLASSIFIED

Woods Hole Oceanographic Institution
Reference No. 63-42

OCEANOGRAPHIC AND UNDERWATER ACOUSTICS RESEARCH, conducted during the period 1 May - 31 October 1963, 40 pp. November 1963.

Unclassified

This is a report of the research program under contracts Nonr-4029 (1 May - 31 October 1963), and Nonr-3243 (1 May - 31 October 1963). Both contracts are with the Office of Naval Research, Code 466. Contract Nonr-4029 is a continuation of Contract Nonr-1367.

Under Contract Nonr-4029, ATLANTIS II and CHAIN, in May and August, were employed in searching for the sunken submarine THRESHER by various means. Under the same contract, activities were devoted also to the development of systems or components of systems for search and for navigational control required in such operations. One system of submerged navigation was employed for locating suspended instruments by acoustic ranging from the ship. A second navigation system was also tested which depends on acoustic ranging either from the ship or from the suspended instrument to a hydrophone buoyed near the bottom. This hydrophone is connected to a radio link in a surface buoy. This system will be useful not only for navigation but also for bottom reflection studies. A program has been started to print and mount all photos taken by WHOI on the THRESHER search; it will be coordinated with other similar efforts in the continuing investigation of the disaster.

1. Progress Report
2. ATLANTIS II
3. CHAIN
4. THRESHER

1. Woods Hole Oceanographic Institution

This card is UNCLASSIFIED

Woods Hole Oceanographic Institution
Reference No. 63-42

OCEANOGRAPHIC AND UNDERWATER ACOUSTICS RESEARCH, conducted during the period 1 May - 31 October 1963, 40 pp. November 1963.

Unclassified

This is a report of the research program under contracts Nonr-4029 (1 May - 31 October 1963), and Nonr-3243 (1 May - 31 October 1963). Both contracts are with the Office of Naval Research, Code 466. Contract Nonr-4029 is a continuation of Contract Nonr-1367.

Under Contract Nonr-4029, ATLANTIS II and CHAIN, in May and August, were employed in searching for the sunken submarine THRESHER by various means. Under the same contract, activities were devoted also to the development of systems or components of systems for search and for navigational control required in such operations. One system of submerged navigation was employed for locating suspended instruments by acoustic ranging from the ship. A second navigation system was also tested which depends on acoustic ranging either from the ship or from the suspended instrument to a hydrophone buoyed near the bottom. This hydrophone is connected to a radio link in a surface buoy. This system will be useful not only for navigation but also for bottom reflection studies. A program has been started to print and mount all photos taken by WHOI on the THRESHER search; it will be coordinated with other similar efforts in the continuing investigation of the disaster.

1. Progress Report
2. ATLANTIS II
3. CHAIN
4. THRESHER

1. Woods Hole Oceanographic Institution

This card is UNCLASSIFIED